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*THE PROBLEM OF DEVELOPMENT.**

THE selection of such a subject as the problem of development for a general address to this academy as a whole suggests a word of explanation. Within the privacy of our sectional meetings we are permitted to dig and delve as much as we please among the dry bones of specialization; but on this occasion a righteous tradition imposes upon the president the duty of laying aside his special tools in order to address the whole scientific body over which he has for a time had the honor to preside. In offering a brief general dis-

* Annual address of the president, New York Academy of Sciences, December 19, 1904. The critical reader will, I hope, be willing to bear in mind the conditions under which this address was delivered. My endeavor was to convey to a scientific body, composed only in part of biologists, some individual impressions of a student of embryology and cytology regarding the general bearings of recent researches in his special field. It was not consistent with this purpose to give a critical résumé for biologists, nor could authorities be cited in detail. The general conception here developed will recall certain views contained in Driesch's 'Analytische Theorie der organischen Entwicklung,' published in 1894 (themselves traceable to earlier conclusions of de Vries), but afterwards rejected by him in favor of an explicit theory of vitalism. The rediscovery of Mendelian inheritance, the newly produced evidence, on the one hand, of morphological and physiological diversity among the chromosomes; on the other, of protoplasmic prelocalization in the egg, have, however, placed the whole problem in a new light. I wish to acknowledge my indebtedness to Professor Whitman's fine essays on the questions that center in Bonnet's doctrines, published in the 'Wood's Hole Biological Lectures,' for 1893, which suggested the quotation from Huxley.

cussion of some latter day problems of embryology and cytology I shall endeavor not to violate the spirit of this tradition. The task is not an easy one, owing to the complexity of the data and their strangeness to those who have not closely followed the details of modern biological work; yet I am encouraged to make the attempt by the belief that the problem of development belongs to those larger scientific questions that are of enduring interest to all students of nature. It is only fair to point out, however, that a consideration of recent advances in this subject necessarily and speedily leads us into a region that lies remote from everyday experience, surrounded by arid wastes of technical detail, and inhabited by folk who speak an uncouth foreign tongue. With the best of intentions, therefore, the native guide and interpreter has need of some forbearance on the part both of his countrymen and of the outlanders whom he attempts to lead.

I need not dwell on the absorbing, almost tantalizing, interest with which the problem of development has held the attention of naturalists from the earliest times. Twenty centuries and more have passed since Aristotle first endeavored to trace something like a rough outline of its solution. The enormous advances of our knowledge during this long period have taken away nothing of the interest or freshness of the problem; they have left it, indeed, hardly less mysterious than when the father of science wrote the first treatise on generation. I will not dwell on the epoch-making work of Harvey, Wolff and von Baer, or the curious, almost grotesque controversies of the eighteenth century, when embryology invaded the field of philosophy and even of theology. I will only point out that even at that time, when embryology was almost wholly limited to the study of the hen's egg, embryologists were already occupied with two fundamental questions, which still remain in their essence without adequate answer, and though metamorphosed by the refinements of more modern observation and experiment still stand in the foreground of scientific discussion. The first of these is the question of preformation *versus* epigenesis—whether the embryo exists preformed or predelineated in the egg from the beginning or whether it is formed anew, step by step, in each generation. The second question is that of mechanism *versus* vitalism—whether development is capable of a mechanical or physico-chemical explanation, or whether it involves specific vital factors that are without analogy in the non-living world. It is especially to some modern aspects of these two questions that I invite your attention; and I shall also consider briefly their relation to recent conclusions affecting our theories of heredity and evolution.

Let us first seek to define more clearly the meaning of our terms. The embryologists of the pre-Darwinian period, unhampered by historical conundrums, fixed their attention on the single objective problem of the nature of the germ and its mode of development. The hen's egg contains something which, though not visibly a bird or even an embryo, will when maintained at a temperature of about 37° C. for 21 days cause a living chick to step forth from the shell. What is that something and what manner of machinery (if machinery it be) is set in motion to work such a marvel? The early embryologists found no real answer to this question. They determined the fact that at the beginning the egg contains nothing even remotely resembling a bird; that as early as the second day a rudely fashioned embryo is visible in the egg; and that day by day, as the incubation proceeds, this embryo becomes more complex. The bird appears to be progressively created out of something that is without form and void

of visible structure. Its development, said Harvey and Wolff, is essentially a process of 'epigenesis'—a successive formation and addition of new parts not previously existent as such in the egg. This conclusion, roughly outlined by Aristotle, was apparently established on an irrefragable basis of observation, long afterwards, by Harvey and Wolff. In its superficial aspects the doctrine of epigenesis is no more than a statement of universally admitted fact. When followed to its logical end, however, this conception has failed, and will always continue to fail, to satisfy the mind; and some of the most acute of modern embryologists have expressed the opinion that no thoroughgoing hypothesis of epigenesis can be so framed as to be logical, or even conceivable.[su] Even in the eighteenth century this doctrine was met by the opposing one of preformation and evolution. Advocated by such men as Malpighi, Haller and Leibnitz, this conception underwent its fullest development in the hands of the eminent Swiss naturalist Bonnet. Developed with great logical acuteness and set forth with captivating literary skill, Bonnet's theory was based on the fundamental assumption that the embryo, though invisible, really exists preformed in the egg before development begins. The preformed germ was not conceived to be an exact miniature model of the adult. On the contrary, Bonnet thought of the germ of the fowl, for example, as differing widely in form and proportions from an actual bird, still the original preformation was assumed to be composed of parts that correspond, each for each, to the parts of the chick. Development, accordingly, was conceived to be only the unfolding and transformation of a preexisting structure, not the successive formation of new parts—a process of 'evolution,' not of epigenesis. In this particular form the doctrine of preformation was conclusively overthrown by Wolff; but the principle underlying it has repeatedly and persistently reappeared in later speculations on development, and still contests the field of discussion with its early antagonist.

Hand in hand with this controversy has gone one of still more general scope between the two opposing conceptions that I have referred to as mechanism and vitalism. Is development at bottom a mechanical process? Is the egg a kind of complex machine, wound up like a piece of clockwork, and does development go forward like the action of an automaton, an inevitable consequence of its mode of construction? Or, on the other hand, does development involve the operation of specific vital entelechies or powers that are without analogue in the automaton and are not inherent in any primary material configuration of the egg? This question, I hardly need say, is included in the larger one, whether the vital processes as a whole are or are not capable of mechanical explanation. As a problem of embryology it is very closely connected with that of preformation or epigenesis, and in point of fact the two have always been closely associated. Evidently, by its very form of statement, any theory of preformation or prelocalization in the germ assumes at least a mechanical basis for development, *i. e.*, a primary material configuration upon which the form of development in some measure depends. With theories of epigenesis the case is not so clear; for such theories may or may not be mechanical. Without further preamble I now ask your attention to certain facts which will place clearly before us the form in which these time-honored problems appear to us to-day.

It is a familiar fact that development begins with the progressive segmentation or division of the egg into cells, which, continually increasing in number, finally build up the body of the embryo. Until com-

paratively recently it was not suspected that the cells thus formed in the earliest stages had any constant and definite relation to the parts of the future body. The fact has how been established, however, that in a large number of forms (though apparently not in all) such a definite relation exists, both the form of division and the prospective values of the cells being constant. In the egg of the ascidian, for instance, the first cleavage-furrow passes pretty accurately through the future median plane of the body, and the two cells thus formed give rise respectively to the right and left sides of the embryo. In a snail's egg the relation is a different one, but is no less definite and constant; in the four-cell stage, for instance, the material that will produce the shell and foot is located, mainly at least, in one of the four

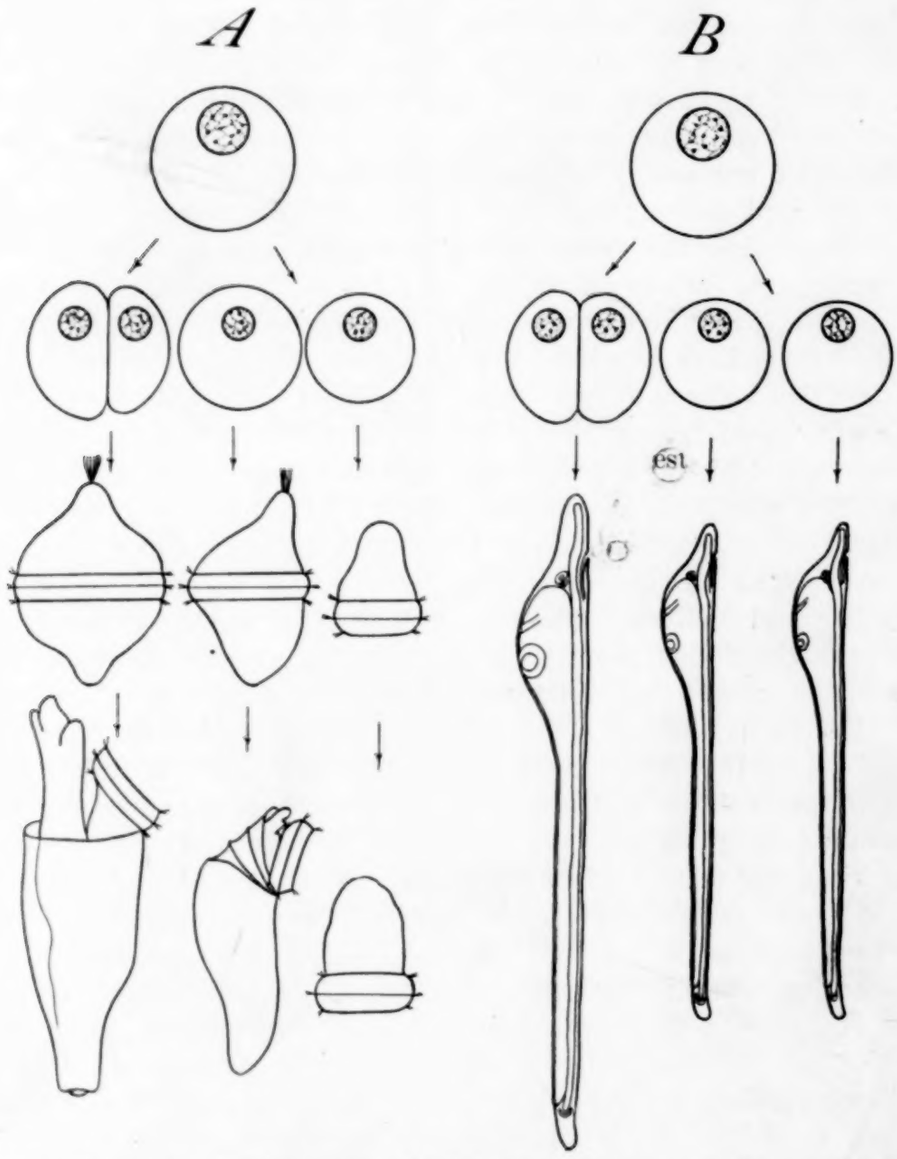

Fig. 1.—Development of entire eggs and of isolated blastomeres of two-cell stage. *A, Dentalium;* at the left, development of the whole egg; at the right, development of the isolated first two cells, producing two defective larvæ. *B, Amphioxus;* the corresponding experiment, isolated cells producing two perfect dwarfs.

cells. Again, in a worm's egg, after its segmentation into sixteen or more cells, we know very exactly how the materials for the head, the segmented trunk-region, the digestive tract, the muscles and the ganglia, are distributed among these cells. In all such cases the embryo seems comparable to a piece of mosaic-work, each cell apparently having its own inherent particular character, and its own specific rôle to play.

These facts place very conspicuously before us a modern form of the problem of preformation which we may conveniently call the problem of 'germinal *prelocalization.*' Does this mosaic-like character of the early embryo mean that the cells are inherently different? Are they in any degree individually predestined for their future development; and if such be the case, can this predestination be traced back to protoplasmic regions in the egg before it has divided into cells? In other words, does the egg, or does it not, contain prelocalized, predetermined areas that have any necessary or causal relation to the parts of the future embryo? This is the first guise in which the old question of preformation presents itself to us to-day. I ask you to glance at the results of a few very simple experiments designed to test this question. They will give apparently quite contradictory results.

Experiments on the eggs of certain animals, such as ctenophores or mollusks, seem to give an unequivocal answer to our questions. If, for example, the cells of the segmenting egg of the mollusk *Dentalium* or *Patella* be separated from one another, at the two-cell stage or any later period, they continue to develop and produce living, actively swimming structures; but these creatures are not completely formed whole embryos, but monsters that in many respects resemble pieces of a single embryo (Fig. 1, *A*). It is true that the wounds usually close and heal; but these structures, nevertheless, remain monstrous and defective, and if they are carefully studied it is found that only when taken collectively can they be said to constitute a single whole embryo. The cells are thus proved to be in some measure inherently different, and to this extent the cell-mosaic is shown to be a real mosaic. If we now extend our operation to the undivided egg, a result in harmony with this is reached. If certain portions of the egg of *Dentalium* be artificially cut off, the remaining portion, upon fertilization, regularly gives rise to a defective and monstrous creature that is not a whole embryo, but resembles a piece or fragment of an embryo. It is evident that this experiment seems to show pretty clearly that even before the egg has begun to divide into cells the parts of the future embryo are in some measure definitely prelocalized and predetermined in its different protoplasmic regions; and evidently, if this be the case, we seem further to have good ground for the mechanistic assumption that the undivided egg contains some kind of structural or material configuration upon which the character of the development depends.

But let us not on this account too hastily accept a theory of preformation or prelocalization. Let us first look at the results of an exactly similar experiment performed on the egg of certain other species of animals, for example, *Amphioxus,* a sea-urchin, or a nemertine worm. Separate here the first two or four cells, and each develops, not into an abortive monster, but into a perfectly formed though dwarf larva (Fig. 1, *B*). Thus it is possible to produce from a single egg from one to four perfect animals; and in case of certain species (hydromedusæ) it is theoretically possible by a similar method to produce from a single egg as many as eight or even sixteen perfect dwarfs. Again, in some of these cases, for instance in the nemertine,

the undivided egg may be cut to pieces in any planes taken at random; yet every piece, if of sufficient size, may upon fertilization develop as if it were a whole egg and produce a perfect dwarf. Here is an astounding contrast to the results of our first experiment. What becomes of our theories of prelocalization here, and what becomes of our mechanical theory of development, if we hold such a theory? Neither the cells nor the regions of the egg seem to have any predestination such as is shown in the molluscan egg. It is the essence of a machine or automaton that its operation is due to its structural configuration. Impair or destroy that configuration and the action ceases. But from these eggs we may take away any of the parts, or the

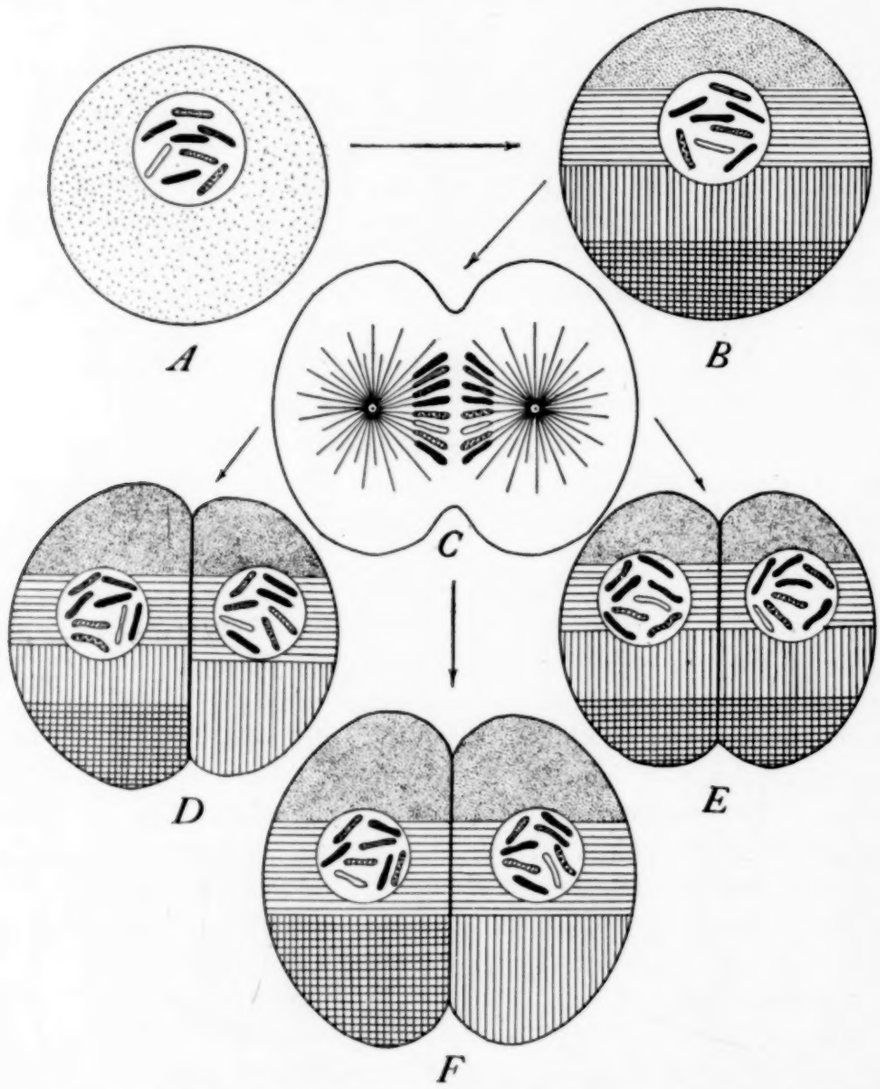

Fig. 2.—Diagram of protoplasmic zones and their distribution at the first cleavage in different forms. *A*, immature egg, assumed to have no definite segregation of protoplasmic stuffs. *B*, mature egg, with protoplasmic zones of horizontal stratification. *C*, first cleavage, division of the chromosomes. *D*, *E*, *F*, different types of two-cell stage. *D*, Dentalium type the lower zone isolated in one cell. *E*, *Amphioxus*, nemertine, or echinoderm type; equal division of the zones. *F*, hypothetical type with complete separation of two zones at the first cleavage.

whole may be cut to pieces, yet there is no impairment of action, but only a readjustment to form smaller systems like the original whole. The egg, therefore, says the vitalist, can not be an automaton and its development is inexplicable upon a mechanical theory.

Such is the paradoxical result to which a superficial comparison of these two cases leads us—a kind of embryological antinomy, as it were, which at first sight may seem to take away all hope of finding law or order in these phenomena. I will undertake to show you speedily that the apparent contradiction is easily explicable. I have placed the two cases side by side because each seems to demonstrate the truth of one side of an ancient embryological controversy; and we shall presently find reason for the conclusion that each of the opponents, like the two knights and the shield, have recognized but a part of the truth.

The probable explanation of the difference of the behavior between the eggs of *Dentalium* and of *Amphioxus* is a very simple one. When we closely study eggs of this type we find that they do not consist of homogeneous protoplasm, but of different kinds of protoplasmic materials or stuffs that are at the outset arranged, roughly speaking, in horizontal bands or strata, as indicated in the diagram (Fig. 2, *B*), where the number of strata is arbitrarily assumed to be four. Now, an examination of the manner in which the egg divides gives strong reason for the conclusion that in such forms as *Amphioxus* the first division bisects these stuffs, so that each of the first two cells receives one half of each stratum (Fig. 2, *C, E*). In the egg of *Dentalium*, on the other hand, this is demonstrably not the case, for the lower stratum passes over bodily into one of the cells and is quite excluded from the other (Fig. 2, *D*). The symmetrical division in *Amphioxus*, the sea-urchin, or the nemertine, gives the immediate possibility of producing two smaller systems similar to each other and to the whole egg. The symmetrical or qualitative division in *Dentalium*, on the other hand, does not give such an immediate possibility, for it produces two different systems neither of which is identical with that of the entire egg. It is highly probable that we find here a proximate explanation of the fact that each of the two cells in *Amphioxus* may produce a perfect dwarf, while in *Dentalium* neither produces such a larva. Facts like these are leading us to the conclusion that the immediate determining causes of development are to be sought in specific protoplasmic stuffs, or organ-forming materials, that are distributed to the cells in a definite way during division. These materials, definitely arranged, are sometimes plainly visible in the undivided egg. I have, for instance, been able to show that the egg of *Dentalium* contains an area of protoplasm at the lower pole that has a causal connection with the formation of the foot and shell, and probably also of the principal part of the mesoblast structures; for if this area be cut off from the unsegmented egg the resulting embryo regularly lacks these structures. In like manner, Professor Conklin has recently been able to recognize in the protoplasm of the unsegmented egg of a species of ascidian the material of the future tail-muscles of the larva; and though no necessary connection between this material and the muscles has thus far been experimentally proved, my experiments on *Dentalium* leave by analogy little doubt that such a causal connection exists. We do not in the least know how these protoplasmic stuffs or materials act. We can hardly imagine how it is that one kind of stuff involves the development of muscles, others that of nerves, ciliated cells, or shell-secreting cells. We may guess that

these stuffs may be analogous to the so-called internal secretions, formed in the adult organism by such organs as the thyroid or the sexual glands, which are known to produce quite specific morphological effects on the body. A second guess is that the formative stuffs may be related to the soluble ferments or enzymes, which in other ways play so great a rôle in the economy of plants and animals.

But, aside from this question, the evidence is steadily increasing, I think, that such stuffs exist, that they have a definite arrangement in the egg, and that in cases where the form of cleavage is constant they are distributed in a definite way to the cells into which the egg splits up. The cleavage-mosaic is accordingly to be conceived as an actual mosaic of different materials that are somehow causally connected with the development of particular parts. When these materials are equally distributed by the earlier divisions, as in *Amphioxus,* each of the resulting cells may upon isolation produce a perfect larva; when they are unequally distributed, as in *Dentalium,* the cells are no longer equivalent, and upon being isolated produce the structures corresponding to the particular stuffs allotted to them.* These facts will presently bring us to our first general conclusion. First, if the protoplasm contain such stuffs, grouped and distributed in a definite way, to just this extent may development receive a mechanical interpretation—that is, be conceived as the result of an antecedent material configuration in the egg-protoplasm. We have as yet no very distinct idea regarding the degree of complexity of this initial protoplasmic configuration, though there are facts that indicate that it may not be very great, *i. e.,* that the prelocalization is of a somewhat general character. This question appears, however, to be of relatively minor importance in view of an additional conclusion given by detailed studies on the formation, maturation and early development of the egg. These studies leave no doubt that the grouping of materials observed at the time the egg begins its process of division is not, in some cases at least, a primary or original one, but is of secondary origin. They indicate further that early in the development the egg contains only a few of these specific stuffs, at the very beginning possibly none, and that as development goes forward new stuffs are progressively formed and distributed. Now, if this conclusion is well founded, the actual progressive development of the protoplasm must be conceived as a process of *epigenesis,* not of preformation and evolution. This is the first general result that I desire to emphasize; and it is in harmony with the fact, on which all embryologists have been agreed, since the time of Wolff, that in its obvous features development is by the formation and addition of new parts not previously existent as such in the egg. The embryo is not actually preformed or even predelineated in the protoplasm from the beginning. The protoplasmic stuffs appear to be only the immediate means or efficient causes of differentiation; and we have still to seek its primary determination in causes that lie more deeply. We are thus led to a brief consideration of the question of the physical basis of heredity, which will direct our attention to an element that has hitherto been disregarded, namely, the nucleus, and bring us to a second general result.

It was long since suggested by Nägeli

* It will appear in the sequel that even in the latter case the potentiality of producing a complete embryo may still be present in the nucleus. It is important to distinguish between such primary or original nuclear potentiality, which may be common to all the cells, and the secondary or immediate potentiality determined by protoplasmic specification. The relation between these is still an unsolved problem.

that there is a particular substance or 'idioplasm' peculiar to each species of plant or animal that is transmitted in the germ-cells and has the power to determine the development of the egg according to its nature. Later research has given very strong reason to accept this view in principle, and for the further conclusion that this physical basis is represented by a substance contained within the nucleus and known to cytologists as 'chromatin.' Passing over the cogent, and I believe steadily accumulating, evidence on which this conclusion rests, let us ask how the idioplasm is to be conceived. Some of those who have accepted the general conception of the idioplasm have endeavored to think of it as a very complex but still single and homogeneous substance—the frog's egg, for example, might be conceived as containing a frog-determining substance, the human germ a man-determining substance, and so on. The most recent researches are, however, continually strengthening the ground for a quite different conception, indicating that the chromatin does not operate as a simple substance, but is built into a complex fabric having a definite architecture. We are not here concerned with the particular form of this conception developed by Weismann in his well-known work on the *Germ-plasm*, and elsewhere. I am referring to more recent results of observation and experiment which are giving new and more concrete evidence that the nucleus possesses a complex organization, and apparently one that must be conceived as a kind of primary or original preformation, which bears a certain analogy to that assumed by Bonnet, though quite distinct from it.

We may perhaps most readily approach the grounds for this conclusion by considering, first, an example of the indirect evidence drawn from recent experiments on inheritance. I give a single example, typical of a large number of known cases, of the heredity of single or unit characters in the so-called Mendelian inheritance. If pure gray mice be crossed with pure white albino forms, the hybrid offspring are all gray without visible trace of white. But if these gray hybrids be now paired with each other, both parents being gray, approximately 25 per cent. of their progeny are pure white without a trace of gray, and they continue to produce pure white offspring thereafter. Many similar cases are known, the same proportion of approximately 25 per cent. of the 'recessive' character in the third generation holding true, sometimes with great precision. What does this prove? First, that the white character is not really absent in the gray hybrids but only masked or concealed—'recessive,' in Mendel's terminology; secondly, that the latent white character may in the following generation be completely disentangled or extracted from the gray; thirdly, since the proportion is definite, that the extraction takes place by means of some definite mechanism. We are at present, I think, unable to imagine an explanation of these truly astonishing facts save by the assumption that the gray and white characters are borne in the egg by corresponding discrete bodies or entities of some kind, that may be mixed and unmixed without fusion, shuffled and unshuffled like cards in a pack. The evidence is so far wholly indirect, though I think none the less cogent. But now, bearing in mind that the case of the gray and white mice is but a single example of a widespread phenomenon, let us ask whether we can actually find any definite structures in the egg, and particularly in the nucleus, that may be assumed to represent such entities. One of the most significant and remarkable discoveries of modern biology is the fact that such entities exist, though it is important not to forget that their significance in heredity is

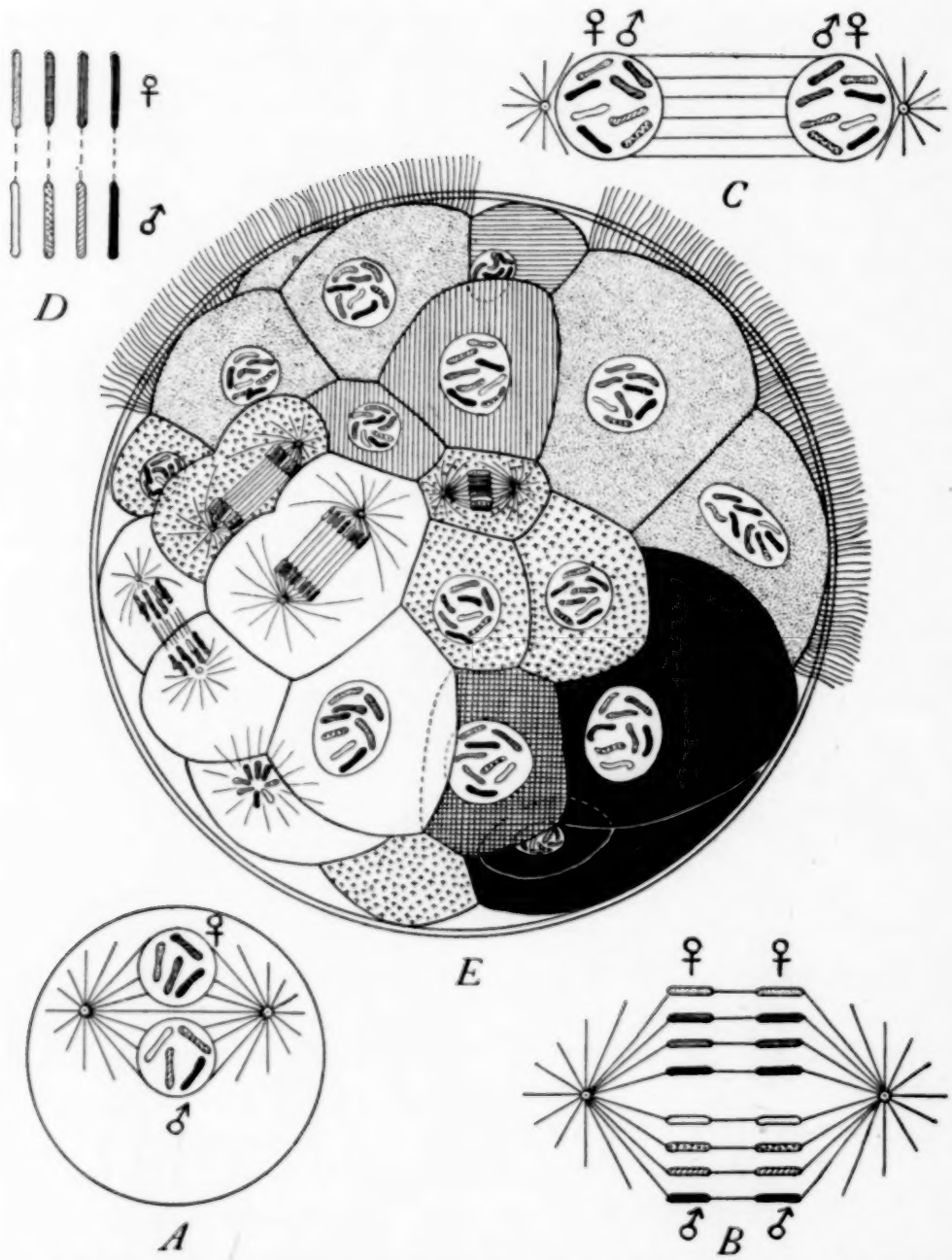

FIG. 3.—Relations of the chromosomes; formation and distribution of protoplasmic stuffs in later stages. *A*, union of the germ nuclei (each assumed to have four chromosomes). *B*, *C*, division of the chromosomes, with equal distribution of the paternal (♂) and maternal (♀) products. *D*, scheme of nucleus at any later stage, with four paternal and four maternal chromosomes (corresponding or homologous chromosomes connected by dotted lines). *E*, actual outline (after Mead) of egg of *Amphitrite* consisting of upwards of 64 cells (nuclei schematized). Entoblast-cells unshaded, primary mesoblast cross-hatched, trochoblasts (ciliated cells) dotted, cells of ventral plate (ventral nervous system, etc.) black; the other cells belong to the ectoblast.

as yet only an assumption, not a completely demonstrated fact.

These entities are bodies known as 'chromosomes,' and are represented in the diagrams by the rods in the nuclei.* I can not within the limits of this address attempt to do more than touch on a few of the discoveries of recent years regarding the chromosomes, though I think they may

* In point of fact the chromosomes are, as a rule, only distinctly visible at the period of cell-division. In the diagram they are represented quite schematically, as if visible in the resting nuclei.

fairly be claimed to constitute one of the most brilliant chapters in the whole history of biology. The number of the chromosomes is constant in each species and, with only a few exceptions of such a kind as to emphasize the rule, the number in sexually produced organisms is always an even one. It has been proved that during the fertilization of the egg one half of the chromosomes are derived from the father and one half from the mother (Fig. 3, *A*), and the still more suggestive fact has been established—with probability through the study of normal development, with almost complete demonstration through the study of hybrids—that at every division of the egg the chromosomes also divide (Figs. 2, *C*, 3, *B*, *C*) in such a manner that their progeny are distributed in equal number, step by step, to all the cells of the body. The remarkable conclusion is thus reached that the fertilized egg, and all the cells derived from it, contain a double set of chromosomes, paternal and maternal (Fig. 3, *D*). The no less interesting result has been experimentally reached that either set—paternal or maternal—is sufficient for complete development (at least as far as the larval stages); for the egg may be caused to develop without the paternal chromosomes, while conversely the paternal chromosomes alone will suffice for the development of an egg from which the maternal nucleus has been removed. Here for the first time we catch a glimpse of the probable physical explanation of the phenomena of dominance and recession that have of late so greatly aroused the interest of experimenters on inheritance; but above all, here is found our first definite basis of observation for the assumption that the nuclear organization is not merely a chemical or molecular one, but represents beyond this some kind of definite material configuration of the nuclear substance.

The time will not allow me to do more than touch on the very recent work that has confirmed and extended this conclusion. It has been found, first, that in some species the chromosomes show constant differences of shape and size, which points towards the conclusion that they may possess specific individual characters. But beyond this indirect evidence, and quite independently of it, Boveri has shown by direct experiments of great ingenuity and beauty that qualitative physiological differences among the chromosomes actually exist; for complete development is only possible in the presence of a particular combination of chromosomes. Hence the conclusion becomes probable that there is a definite causal relation of some kind between the individual chromosomes and the development of corresponding characters or groups of characters; or, in other words, that the hereditary characters are in some manner distributed among the chromosomes which form their physical basis in the egg. We do not yet know in precisely what form this conclusion should be formulated. We do not know, for instance, whether a single unit-character, such as color, is determined by a single chromosome, or by a combination of chromosomes, or whether this may vary in different cases. In this direction we have taken but the first uncertain steps towards a new horizon of discovery. But the point I wish to emphasize is that if we admit such a distribution of characters among the chromosomes in any measure and in any form, to just this extent have we admitted the principle of preformation as applied to the nuclear substance or idioplasm. To this extent do we admit, for example, that the physical basis of inheritance in a frog's egg is not simply a frog-determining *substance*, but is, in close analogy with Bonnet's conception, a kind of original preformation or microcosm, in which the individual frog-

characters are in some unknown manner represented by corresponding chromosome-characters. We can hardly imagine at present how this is possible; and it must be freely admitted that such a conclusion has an appearance of artificiality and crudeness that almost inevitably creates a certain feeling of scepticism. Nevertheless, to a conclusion similar in principle to this the facts seem to be pretty definitely pointing.

And now, finally, let us see how this conception, if accepted, is to be united with that of specific protoplasmic stuffs, as already outlined. We do not know in any positive way, but we may roughly present the facts to our minds by a kind of artificial hypothesis—somewhat as Ehrlich and his followers endeavor to present the side-chain theory of immunity by means of rough and crude diagrams. Let us assume, for example, that the specific protoplasmic stuffs are formed one after another by means of substances like enzymes that emanate from corresponding chromosomes.* Putting the matter in the sharpest and crudest way, let us assume that each of the chromosomes in our diagram is responsible for the formation of the stuff correspondingly shaded. A few of these stuffs, formed and distributed as the egg ripens, determine the initial stages of development. In later stages other stuffs are formed by other chromosomes and progressively distributed to the cells by division. Thus the cleavage-mosaic grows progressively more complex and definite as development advances. Each nucleus still contains the germ or potentiality of the whole organism, but the cells assume specific characters according to the protoplasmic stuffs allotted to them (Fig. 3, *E*).

This attempt to portray briefly the *modus operandi* of development is doubtless an excessively naïve mode of formulating a highly complex and subtle process, concerning the real nature of which we still know very little. Even if literally correct it would still leave quite out of account some of the most important elements of our problem. I do not offer it as a well-established or fully rounded conclusion, but rather as a convenient way of placing before you one fundamental result, towards which I believe the drift of recent research is tending. This is that the germ consists of two elements, one of which undergoes a development that is essentially epigenetic, while the other represents an original controlling and determining element. The first is represented by the protoplasm of the egg. The second is the nucleus, which, as I have attempted to show, must apparently be conceived as a kind of microcosm or original preformation, consisting of elements which correspond, each for each, to particular parts or characters of the future organism. The actual development of the embryo, which is manifested by progressive changes in the protoplasm, is by epigenesis, as Harvey and Wolff maintained. Its primary determination is by means of a preformed apparatus, handed on to the egg from preceding generations in the nucleus, which, though not in any sense a miniature model of the adult, yet somehow embodies in infinitesimal compass, the heritage of the race. And thus the most recent discoveries in this difficult field of research are bringing us to a position which can hardly be better stated than in the words written by Huxley more than thirty years ago: "The process which in its superficial aspect is epigenesis appears in essence to be evolution, * * * and development is merely the expansion of a potential organism or original preformation according to fixed laws." We should not, with the advantage of our present standpoint, read into these words of Huxley's a meaning which it was impossible

* *Cf.* Driesch's 'Ferment-Fiktion,' Analyt. Theorie, pp. 87–92.

that he should have had in mind in writing them; yet without yielding to this temptation we may fairly pay our humble tribute of admiration and homage to a scientific insight that was capable of reaching such a conclusion in the far away prehistoric period when chromosomes and Mendelism were unsuspected, when the nature of fertilization was unknown, and the internal mechanism of development was a wholly unsolved riddle.

I will in conclusion add only a few words on the question of vitalism and mechanism in the light of the foregoing results. In so far as development may be conceived as the outcome of an original material configuration in the nucleus, and a secondary configuration in the protoplasm, it may be conceived as a mechanical process. But it must be admitted that this conception leaves quite unsolved certain fundamental elements of our problem --such, for instance, as the manner and order in which the protoplasmic stuffs are formed and assume their characteristic configuration, whether in the whole egg or in the isolated blastomere or egg-fragment; or again, how the wonderful phenomena of the regeneration of lost parts in the adult organism can be explained. We have at present no positive data for an answer to these questions. But it can hardly be disputed that we have already made a considerable advance towards a mechanical solution of the problem, and if this be so, by what right does the vitalist demand that we shall adopt his hypothesis for the portions still unsolved? Let us seek an answer to this question in the answer to a broader one. What is the object of the study of development? I should state this object somewhat as follows: First, to observe and to describe as completely and simply as possible the actual phenomena of development; secondly, to determine to what extent, from its beginning in the egg to its completion in the adult organism, the process can be formulated in terms of the elementary laws of matter and of motion. But this is only a different way of stating that our object is to ascertain in what measure the operations of development, under given external conditions, are the result of an original configuration of material particles in the egg. Now, I do not need to say that even the approximate accomplishment of these aims is still very remote, their complete accomplishment impossible. I am fully in accord with the neo-vitalists in their assertion that the phenomena of development and of life generally have not yet been reduced to a mechanical basis, that they can not at present be fully described in physico-chemical terms. It is certain that living beings exhibit structures more complex than any existing in the inorganic world, and different from them in kind. It is possible, probable I believe, that living bodies may be the arena of specific energies that exist nowhere else in nature. I admit fully that the interpretation of development I have endeavored to outline does not exclude, but in some ways actually suggests, the existence of such energies. I should, therefore, even admit that the vitalists are wholly right in their contention that the vital processes are not at present explicable as the direct result of such energies as are observed in the non-living world. To prejudge this question would set up a dogmatic barrier to progress, not only in biology, but also in chemistry and physics. If this be vitalism there are probably many of us who must be enrolled as 'vitalists,' however doubtfully we may regard the honor of bearing such a title. But if the word 'vitalism' be used in any other sense than as a convenient phrase, an x by which to designate an unknown quantity, if it be taken in a positive sense to imply in the living organism any negation of the funda-

mental laws of matter and of motion, the existence of any distinctive entity, or principle that does not fall within the chain of physical causation or that contravenes the general laws of physics, then, I protest, to accept 'vitalism' as a principle of interpretation is deliberately to abandon the scientific method in biological study.

Edmund B. Wilson.

THE AMERICAN PALEONTOLOGICAL SOCIETY. SECTION A—VERTEBRATA.

Section A of the American Paleontological Society held its third annual meeting in common with the other societies on December 27, 28 and 29, and greatly enjoyed the admirable arrangements made by the officers of the University of Pennsylvania, especially by Professor Conklin. The President, Professor Henry F. Osborn, presided. At the close of the meeting Professor W. B. Scott was elected president and Dr. Marcus S. Farr secretary, both of Princeton University.

The meeting included a series of eighteen papers presented in person or in manuscript by Messrs. Osborn, Eastman, Sinclair, Case, Lull, Patten, Brown, Gidley, Hay, Loomis, Farr, Scott, Petersen, Douglass, Williston, Matthew and Granger. These were presented on Tuesday afternoon and on Wednesday and Thursday mornings. On Wednesday forenoon the president delivered his annual address, entitled 'Ten Years' Progress in Mammalian Paleontology.' In this address, which will be printed in full elsewhere, the history of the science during the last decade was followed in detail, and the principal advances, in the discovery of new forms, principles, and methods of work, were outlined. On Thursday morning the principal feature was the discussion of the phylogeny and classification of the Reptilia, in which Messrs. Osborn, Williston, McGregor and Hay participated. In this discussion Professor Osborn opened with a general review, pointing out the gradual development of the idea of a double grouping of the reptiles, beginning with Baur's phylogeny published in 1889 and continued in the phylogenies and discussions of Cope, Smith Woodward, Broom, Nopcsa, Williston, Boulenger, Osborn and McGregor. The following table is that of Osborn, 1904.

The chief differences of opinion at present relate to the position of the Ichthyosauria, Sauropterygia and Testudinata, some authors placing the Ichthyosauria as intermediate between the two groups, others placing them frankly with the descendants of the rhynchocephaloid reptiles, as suggested by Baur. Boulenger derives both the Sauropterygia and the Testudinata from the rhynchocephaloid, or diapsidan, group; whereas all other authors take them off from the synapsidan group.

Professor Williston continued the discussion, speaking especially of the Sauropterygia. He first stated that he considered the Sauropterygia and Testudinata as fundamentally separate groups, all their points of likeness being due to analogous evolution, while their points of difference are fundamentally distinctive. He considered the Triassic plesiosaurs Nothosaurus and Lariosaurus, as not ancestral to the Jurassic and Cretaceous plesiosaurs, but as representing an independent offshoot. He maintained that the Proganosauria, represented by the Permian genera *Mesosaurus* and *Stereosternum*, were certainly not ancestral to the plesiosaurs, as held by Seeley and Boulenger. The Testudinata are also widely separated from the Placodontia, and are probably of direct Cotylosaurian origin. The points of convergence are partly correlated with the large size of the paddles of plesiosaurs and turtles, the short tail being correlated with the long propodials in the plesiosaurs, whereas in the

Subclass **SYNAPSIDA** Osborn 1903. Order **Cotylosauria** Cope 1880 (Pareiasauria Seeley 1889).
Superorder ANOMODONTIA Owen 1860. (Theromorpha Cope 1878, in part.)
- Order **Theriodontia** Owen 1876. Suborder Therocephalia Broom 1903.
  Suborder Cynodontia Owen 1861.
- Order **Dicynodontia** Owen 1860.
- Order **Placodontia** *auct. ex* H. von Meyer 1863 Incertæ Sedis.
- Order **Sauropterygia** Owen 1860. Suborder Simosauria *auct. ex* Gervais 1845.
  (Nothosauria Seeley 1882.)
  Suborder Plesiosauria *auct. ex* Quenstedt 1852.
- Order **Testudinata** *auct. ex* Shaw 1802.
  Suborder Pleurodira *auct. ex* Duméril and Bibron 1835.
  Suborder Cryptodira *auct. ex* Duméril and Bibron 1835.
  Suborder Trionychia *auct. ex* Pictet 1853.

Subclass **DIAPSIDA** Osborn 1903.
Superorder DIAPTOSAURIA Osborn 1903.
- Order **Procolophonia** Seeley 1867.
- Order **Protorosauria** Seeley 1887.
- Order **Proganosauria** Baur 1887.
- Order **Gnathodontia** Owen 1680.
  (Rhynchosauria Osborn 1903).
- Order **Pelycosauria** Cope 1878.
- Order **Choristodera** Cope 1877.
- Order **Rhynchocephalia** Günther 1868.
- Order **Parasuchia** Huxley 1875.
  Suborder Aëtosauria Nicholson and Lydekker 1889.
  Suborder Phytosauria Baur 1894 *ex* Jaeger 1828.
- Order **Ichthyosauria** Blainville 1835 *ex* Jaeger 1824.
  (Ichthyopterygia Owen 1860.)
- Order **Crocodilia** Wagler (?) 1830.
  Suborder Mesosuchia Huxley 1875.
  Suborder Eusuchia Huxley 1875.
  Suborder Thalattosuchia Fraas 1901.

Superorder DINOSAURIA Owen 1840.
- Order **Theropoda** Marsh 1881.
  Suborder Megalosauria *ex* Fitzinger 1843.
  (Thecodontia Owen 1860.)
  Suborder Symphypoda Cope 1867.
  (Compsognatha Huxley 1870.)
- Order **Opisthocœlia** Owen 1860.
  (Sauropoda Marsh 1881.)
- Order **Orthopoda** Cope 1866.
  (Predentata Marsh 1894.)

Superorder SQUAMATA Oppel 1811.
- Order **Lacertilia** Owen 1839.
- Order **Mosasauria** *auct. ex* Gervais 1845.
- Order **Ophidia** Brogniart 1802.

Order **Pterosauria** *auct. ex* Kaup 1834.

ichthyosaurs the long tail is correlated with short propodials. In both plesiosaurs and turtles the ilium is directed downward and forward, in correlation with the backward thrust of the paddles; in both, the scapula acquires secondarily a proscapular process. The fundamental characters distinguishing the two groups may be summarized in the table given below.

Continuing the discussion, Dr. J. H. McGregor maintained and expanded his previous argument for the derivation of the Ichthyosauria from the Diapsida, and for the probably secondary nature of the closed condition of the temporal arch region of the skull.

Turtles.	Plesiosaurs.
Vomer (parasphenoid) unpaired.	Paired prevomers.
No posterior parasphenoid process.	A separate parasphenoid.
Opisthotic separate	Opisthotic not separate.
Cervicals eight.	Cervicals 13–76.
Ribs intercentral in attachment.	Ribs diapophysial in attachment.
Ten dorsals.	Twenty dorsals.

Dr. O. P. Hay pointed out the now convincing evidence that the original Testudinata had a closed, or solid, temporal roof

to the skull, as seen in the primitive Amphychelydia, and persisting in the Cheloniidæ; in other words, the production of an open temporal roof is secondary, in the more primitive families it is less reduced, in the lowest families it is still closed. From this original condition reduction has taken place in most forms from behind; in others, as some pleurodires, from below. There is thus no true supratemporal fossa. The parieto-squamosal arch in some pleurodires is proof of the presence originally of a solid roof. The turtles have been derived from the Cotylosauria, possibly through the Chelydosauria. With the Cotylosauria the turtles agree in possessing eight cervical and ten dorsal vertebræ. He pictured the primitive turtle as having a short, broad head, with overroofed temporal region and a short supraoccipital; a short neck consisting of eight vertebræ, with short neural spines, long transverse processes and bicœlous centra; a distinct proscapular process representing a procoracoid; caudal vertebræ with chevrons; a dermal armature consisting of plates of bone overlying the ribs and neural arches, and above this a mosaic of small bones embedded in the skin; a plastron consisting of the clavicles and interclavicle and the lateral elements of a parasternum, outside of which was a dermal armor of small plates. He maintained further that the turtles and the plesiosaurs are so different that they should be placed in different subclasses.

Dr. F. B. Loomis read a paper on 'The Amherst College Expedition to the Wasatch and Wind River Basins in 1904.' A rich collection of Wasatch forms will supplement several of the less known species. One *Eohippus* in which the paraconid is bifid, and a tiny *Anaptomorphus*, only two thirds the size of *A. homunculus*, are among the species. The beds are 2,180 feet thick. In the Wind River basin a new and rich locality was found, six miles above the mouth of Bridger Creek. There were collected at least three species of *Hyopsodus*, four of *Notharctus*, one of *Anaptomorphus*, three of *Paramys*, one of *Oxyæna*, one of *Esthonyx* and two of *Coryphodon*. The latter is represented by teeth and a nearly complete skeleton.

Mr. O. A. Petersen sent a paper entitled 'Suggestions Regarding the Probable Origin of *Dæmonelix*.' It has been regarded as a plant, but the author concludes that it represents the burrow of the extinct rodent *Steneofiber*. In his explorations he found, in the materials filling the burrows, portions of skeletons of the rodent mentioned.

Mr. Earl Douglass presented a paper on 'A New Monotreme-like Mammal from the Lower White River Beds.' The skull was described and drawings of it shown. While presenting numerous resemblances to the monotremes the author expresses some doubts on the relationships.

Professor W. B. Scott, referring to recent work of Roth on the South American Ungulates, held that the ordinal term Notoungulata suggested by Roth should include three grand divisions and subdivisions as follows:

I. Toxodontia.
  Toxodontia.
  Homalodontotheria.
  Typotheria.
II. Astrapotheria.
III. Litopterna.

Among the common characters are the following:

1. The double ankle joint.

2. The pillar on the inner side of the posterior crescent in the lower molars, the homologies of which are at present obscure.

Division I., including the Toxodontia, Typotheria and Homalodontotheria is especially distinguished by (1) swollen auditory region, (2) zygomatic arch ending on

the top of the skull. The Astrapotheria stand apart in the enlargement of the canines, showing analogies with the Amynodontidæ, which are, however, deceptive. Like the Litopterna they lack the auditory expansion. All these ungulates are further distinguished by being entirely hornless.

Dr. O. P. Hay read a paper 'On the Group of Fossil Turtles known as the Amphichelydia.' The author's studies are based on a very complete skeleton of the Jurassic *Compsemys plicatula* in the American Museum and several fine specimens of *Baena*, collected in the Bridger beds of Wyoming. In the members of this superfamily the temporal region is roofed in, there are nasals and a lachrymal bone; the pterygoids exclude the quadrate from contact with the basisphenoid; the cervical vertebræ may be biconcave or one or both ends may be convex; the neck short and adapted for motion in all planes, but more like that of the Pleurodira; the pelvis not suturally articulated with the shell. The group has evidently given origin to the Cryptodira and the Pleurodira, the former retaining the skull structure, the latter group retaining the neck and shell structures.

Papers were also read by Mr. W. J. Sinclair on 'The Marsupials of the Santa Cruz Formation'; by Dr. Wm. Patten, 'On the Structure of the Ostracoderms'; by Dr. M. S. Farr, 'On Mammals from the Fort Union Beds.'

Professor Wm. Patten described the structure of *Bothriolepis*, based on the study of a large number of well-preserved specimens recently obtained by him in New Brunswick. Many specimens were exhibited which illustrated and confirmed the most important features of the description. The structure of the mouth parts, the position of the gills, anus, anal fin and other organs indicate that the Ostracoderms must be separated from all other known subdivisions of the Chordata and raised to the dignity of a separate class.

Professor S. W. Williston reported on an important new locality for Triassic vertebrates on the east side of the Wind River range, near Lander, Wyo., yielding the most important remains which have yet been found in the American Triassic. The collections, which as yet have not been prepared and studied, represent four great groups, as follows: The Labyrinthodontia are represented by very large forms allied to *Metoposaurus*, of Wurtemberg, but generically distinct from it. The Dicynodontia, or Anomodontia, heretofore not represented in America, are apparently represented in portions of a skeleton, including a humerus resembling that of *Platypodosaurus*, and a pelvis remotely suggesting that of *Tapinocephalus*. The teeth named *Palæoctonus* by Cope and referred to a dinosaur, probably belong to members of this group, the affinities of which still require further study. The third group is widely distinct, including an animal with a slender humerus, a scapulo-coracoid with very prominent glenoid fossa, the blade of the scapula being placed at right angles to the lower portion of the arch, the humerus without entepicondylar foramen; the resemblances are rather with the Pterosauria than any other group. The fourth great group is the Phytosauria; here no less than four skulls of the Belodontia were found, all different, probably representing four genera, differing in the elongation of the snout and position of the nostrils, and adding substantially to our knowledge of this group. The author incidentally remarked that he had positively determined that the *Hallopus* Beds near Cañon City, Colorado, are of Triassic and not Jurassic age; these beds contain labyrinthodonts and crocodiles which belong to a higher horizon than that discovered near Lander.

The author further stated that he placed the Como beds as equivalent to the Wealden, and as representing either the upper or middle part of the Lower Cretaceous.

Dr. E. C. Case read on 'Characters of the Chelydosauria.'

The Permian genus *Diadectes* was shown to be a member of the order Chelydosauria of Cope. This order was founded on the genera *Otocœlus* and *Conodectes* and was considered as ancestral to the turtles.

The discovery that *Diadectes* is a member of this order permits a more complete description of its characters from especially perfect specimens collected by the author of the paper.

The members of the Chelydosauria (Diadectidæ and Otocœlidæ) differ from the Cotylosauria (Pareiasauridæ, Pariotichidæ, Elginidæ(?)) by the following characters; and in the same characters approach the Testudinata.

1. There are three pairs of openings through the roof of the skull instead of two; the extra pair being the openings of the *meatus auditus externus*.

2. The palate is very degenerate and the transverse bone is lost or nearly so.

3. The form of the quadrate and its relations to the surrounding bones are directly comparable to those of the turtles.

4. There are no teeth on the pterygoids and palatines.

5. There is no anterior process (parasphenoid) on the basisphenoid bone and correlated with this.

6. There are no prevomers but a single, anteriorly placed vomer (parasphenoid?).

7. The internal carotid arteries do not penetrate the lower surface of the basisphenoid, as in the *Rhyncocephalia*, but enter from the side as in many turtles.

8. The presence of paired descending plates from the under side of the parietal and the possible absence of the epipterygoid.

9. The presence of dorsal plates overlying the dorsal ribs and the presence of eighteen presacral vertebræ (the last common to Cotylosauria).

There is no trace of a beginning plastron.

It is concluded that the characters of the skull establish the validity of the order Chelydosauria and indicate the direct origin of the turtles from the Cotylosauria.

On Eocene Insectivora and on Pantolestes in particular: W. D. Matthew.

The genus *Pantolestes* Cope, variously referred to the Primates, Creodonta and Artiodactyla, turns out to be a fossorial insectivore of an archaic and peculiar type. A well-preserved skull and jaws and a large part of the skeleton were obtained by the American Museum Expedition in the Bridger Basin last summer. The teeth resemble those of the most primitive creodonts, the skull is most like that of the Centetidæ, and unlike the creodont or condylarth skulls; the limbs and feet are specialized for digging, more than in the badger but less than in the moles; the tail is long and very massive, the postsacral vertebræ being larger than the presacrals. *Palæosinopa* Matthew is the Lower Eocene ancestor of *Pantolestes; Pentacodon* Scott, of the Basal Eocene, appears to be a related genus. The addition of the Pantolestidæ and of some undescribed genera recently discovered, and also, if Wortman's assertion is supported by evidence, of the Hyopsodontidæ, to the list of Eocene Insectivora, greatly increases the importance of that order among the Mammalia of the early Tertiary. The present distribution of the Insectivora indicates that they must once have been an abundant and varied group; but fossil insectivores have hitherto been quite rare and for the most part nearly related to the three common living families, the hedgehogs, moles and shrews.

We now recognize the order as an important group in the Eocene, including a considerable variety of primitive types, and showing relationship on the one hand to the Primates, on the other to the Creodonta. *Trigonolestes* Cope, of the Lower Eocene, is not related to *Pantolestes* but is a true artiodactyl.

Dr. R. S. Lull read a paper on 'Footprint Interpretation' of which this abstract is given. The first dinosaur was found in the Connecticut Valley at New Windsor in 1818; but not until the civil war was a specimen brought to light of sufficient perfection to be considered in footprint interpretation. Even then little was known of the true nature of these forms other than that they were saurians. Marsh's restorations, based upon further material discovered at New Windsor, gave the first opportunity for a correlation of the osseous remains with the footprints. The tracks fall into three classes—truly bipedal forms; those of bipedal gait and quadrupedal resting posture; and finally true quadrupeds.

Of the first group the track genus *Anchisauripus* may be correlated with the family of Dinosauria known as the Anchisauridæ; *Gigandipus* has resemblances to *Allosaurus*, though a somewhat smaller form having a sinuous tail trace; in *Grallator* the feet are very small, with limbs of great proportionate length, representing a group of aberrant compsognathoid dinosaurs probably of habits similar to the wading birds. These genera were all Theropoda, or carnivorous dinosaurs. *Eubrontes* includes truly bipedal forms, large, bluntly clawed, probably of herbivorous habits; hence a predentate dinosaur.

The occasionally quadrupedal creatures were as truly bipedal types as those of the first group while moving, but always brought the hands in contact with the ground while resting. The most important genus is *Anomœpus*, an herbivorous dinosaur whose proportions suggest *Hypsilophodon;* while *Otozoum*, a huge creature with a plantigrade foot, having a shelf-like extension of skin around it presumably to support the great weight of the animal in soft mud, has no counterpart among known dinosaurs; and one can form no conception of its probable appearance. Except for its bipedal gait it presents some interesting points of comparison with *Chirotherium* of the Bunter.

Quite a host of quadrupedal tracks are known which must include both Amphibia and Reptilia, but one genus only, *Batrachopus*, can with any degree of certainty be correlated with known types. *Stegomus longipes*, a small Aëtiosaur from Longmeadow, Mass., seems to show proportions, size and length of limb which would make its relationship with *Batrachopus* fairly assured. In this track genus the stride is extremely long and the trackway narrow, implying a form with high stilted limbs and a gait like a cursorial mammal.

Thus far only can we at present interpret fossil footprints with any degree of assurance.

Dr. C. R. Eastman sent a paper entitled 'Fossil Bird Remains from Armissan.' This paper, which is in course of publication by the Carnegie Museum, discusses the paleontological history of gallinaceous birds, and offers a description of a new species of *Taoperdix*, a form related to existing pheasants, and noteworthy as appearing as early as the Upper Eocene. From the type species it differs chiefly in the relative proportions of mandible and wing-bones. The original is preserved in the Carnegie Museum at Pittsburgh, and has been courteously loaned by Dr. W. J. Holland.

Also a paper on 'Anaximander, Earliest precursor of Darwin.' The doctrine of evolution, far from being a purely modern conception, was anticipated in its essential

features by Ionian philosophers of the sixth century B. C. Writers, however, are disagreed as to which of these may properly be considered as the earliest evolutionist. A collation of the extant fragments of Anaximander, with critical interpretation of the same, reveals an acuteness and suggestiveness on the part of their author such as entitle him to high estimation amongst the founders of the main theory.

A paper entitled 'Recent Exploration of a Pleistocene Fissure in Northern Arkansas,' by Mr. Barnum Brown, describes what might be termed a bone mine from which nearly ten thousand identifiable bones were taken.

It is shown that a large number of the animals entombed here have been dragged in by weasels, which are actually found in their lairs in the wall of the fissure. Other carnivorous animals, such as the saber-toothed tigers, probably inhabited this fissure and brought in the remains of deer and hogs.

Thirty-four genera and fifty-five species are recognized. A new genus of skunks, *Brachyprotoma*, is described; also nine new species of different animals.

The fauna is compared with recent and fossil forms and tends to show that the fossil forms are boreal types and that the climate at this latitude was much colder during the Pleistocene period than at present.

Although many of the fossil species can not be separated from living forms, the large number of extinct species places the age of this fauna at some time prior to the middle Pleistocene.

O. P. Hay,
Secretary.

THE ASSOCIATION OF AMERICAN GEOGRAPHERS.

The Association of American Geographers was organized in Philadelphia, December 29, 30, with about fifty members, of whom about twenty-five were present. The following officers were elected:

President—W. M. Davis, Cambridge, Mass.

Vice-Presidents—G. K. Gilbert, Washington; A. Heilprin, Philadelphia.

Secretary and Treasurer—A. P. Brigham, Hamilton, N. Y.

Councillors—R. S. Tarr, Ithaca, N. Y.; Cyrus C. Adams, New York; H. C. Cowles, Chicago.

The object of the association is "The cultivation of scientific geography in all its branches, especially by promoting acquaintance, intercourse and discussion amongst members, by encouraging and aiding geographical exploration and research, by assisting the publication of geographical essays, by developing better conditions for the study of geography in schools, colleges and universities, and by cooperating with other societies in the development of an intelligent interest in geography among the people of North America." No regular publication will for the present be issued by the association, it being the opinion of its members that existing geographical journals afford sufficient opportunity for bringing out their essays. The annual meetings of the association will ordinarily be held in connection with the winter meetings of the American Association; but it is probable that the meeting next year will be held in New York city. A summer field meeting is in consideration.

The desire of the organizers of the association is to bring together the investigating geographers of the country, and to lead those who are working on the organic and inorganic sides of geography on the human, economic, zoological, botanical, climatic, oceanographic and geologic sides of this many-sided subject—to present their results in each other's presence. While full membership is limited to those who have already accomplished some original work, it was suggested that inquiry be made to

learn whether others who have specialized less in geography would care to take associate membership. In any case the meetings of the association will be open to all interested persons, and a special welcome will be given to those whose further work would naturally lead them into the association.

The program of the meeting in Philadelphia included the following papers, all of which were presented by the authors, except where stated as read by title.

BAILEY WILLIS: 'Some Physical Aspects of China.'

F. E. CLEMENTS: 'The Interaction of Physiography and Plant Successions in the Rocky Mountains.' Read by title.

E. HUNTINGTON: 'The Seistan Depression in Eastern Persia.'

L. STEJNEGER: 'The Distribution of the Discoglossoid Toads, in the Light of Ancient Land Connections.'

A. P. BRIGHAM: 'The Development of the Great Roads across the Appalachians.'

R. W. PUMPELLY (by invitation): 'Physiography of the Northern Pamer.'

R. S. TARR: 'Some Instances of Moderate Glacial Erosion.'

D. W. JOHNSON: 'The Distribution of Freshwater Faunas as Evidence of Drainage Modifications.'

H. C. COWLES: 'The Relation of Physiographic Ecology to Geography.'

R. A. DALY: 'The General Accordance of Summit Levels in a High Mountain Region: the Fact and its Significance.'

I. BOWMAN (by invitation): 'Partly Submerged Islands in Lake Erie.' Read by title.

CYRUS C. ADAMS: 'The Improvement of American Maps.' Read by title.

R. E. DODGE: 'The Journal of Geography and its Purpose." Read by title.

F. E. MATTHES: 'The Study of River Flow.'

L. G. WESTGATE (by invitation): 'The Geographic Features of the Twin Lakes District, Colorado.'

N. H. DARTON: 'Geologic Expression in Contour Maps.' Read by title.

H. F. REID: 'The Forms of Glacier Ends.' Read by title.

F. P. GULLIVER: 'Muskeget a Complex Tombolo.' Read by title.

W. LIBBEY: 'The Physical Characters of the Jordan Valley.' Read by title.

W. M. DAVIS: 'A Chapter in the Geography of Pennsylvania.' Read by title.

G. K. GILBERT: 'Moulin Sculpture.'

G. W. LITTLEHALES: 'A New and Abridged Method of Finding the Locus of Geographical Position, and Simultaneously therewith the True Bearing.' Read by title.

In addition to the above, Professor W. M. Davis, in assuming the presidency of the association, presented a brief address on 'The Opportunity of the Association of American Geographers'; this paper will be printed in the *Bulletin of the American Geographical Society*. Most of the papers were accompanied by lantern illustrations, and it should be stated that most of the authors were present, whose papers were read by title, the papers being withheld from presentation for lack of time.

Extracts were read from a letter sent by Professor E. de Martonne, announcing that an international association of European geographers would probably be formed next spring. It was voted to send to Professor de Martonne the best wishes of the American Geographers for the formation of the European association.

Following is a list of the original members of the Association of American Geographers: C. Abbe, Jr., Washington; Ch. C. Adams, Ann Arbor; Cy. C. Adams, New York; O. P. Austin, Washington; R. L. Barrett, Chicago; A. P. Brigham, Hamilton, N. Y.; A. H. Brooks, Washington; H. G. Bryant, Philadelphia; M. R. Campbell, Washington; H. C. Cowles, Chicago; J. F. Crowell, Washington; R. A. Daly, Ottawa, Can.; N. H. Darton, Washington; W. M. Davis, Cambridge; R. E. Dodge, New York; C. R. Dryer, Terre Haute; N. M. Fenneman, Madison, Wis.; H. Gannett, Washington; M. K. Genthe, Hartford; G. K. Gilbert, Washington; J. P. Goode, Chicago; H. E. Gregory, New Haven; F. P. Gulliver, Southboro, Mass.; C. W. Hall,

Minneapolis; R. A. Harris, Washington; A. Heilprin, Philadelphia; R. T. Hill, Washington; E. Huntington, Milton, Mass.; M. S. W. Jefferson, Ypsilanti; Emory R. Johnson, Philadelphia; Wm. Libbey, Princeton; G. W. Littlehales, Washington; C. F. Marbut, Columbia, Mo.; F. E. Matthes, Washington (Camb.); W J McGee, Washington; R. Pumpelly, Newport, R. I.; H. F. Reid, Baltimore; W. W. Rockhill, Washington; R. D. Salisbury, Chicago; E. C. Semple, Louisville; G. H. Shattuck, Baltimore; L. Stejneger, Washington; R. S. Tarr, Ithaca; R. DeC. Ward, Cambridge; B. Willis, Washington.

Albert Perry Brigham,
Secretary.

SCIENTIFIC BOOKS.

Technical Mechanics. By Edward R. Maurer, professor of mechanics in the University of Wisconsin. New York, John Wiley & Sons. 1903.

Elements of Theoretical Mechanics. By Alexander Ziwet, junior professor of mathematics in the University of Michigan. Revised edition of 'An Elementary Treatise on Theoretical Mechanics,' especially designed for students of engineering. New York, The Macmillan Company. 1904.

Die Technische Mechanik. Elementares Lehrbuch für Mittlere Maschinentechnische Fachschulen und Hilfsbuch für Studierende Höherer Technischer Lehranstalten. Von P. Stephan, Regierungsbaumeister, Lehrer an der Kgl. Höheren Maschinenbauschule in Posen. Erster Teil: Mechanik Starrer Körper. Leipzig und Berlin, B. G. Teubner. 1904.

The teacher of mechanics who undertakes to write a text-book for students of engineering is confronted with a difficult problem. He is compelled to recognize the justice of the demand that the course shall be practical, while resisting the tendency to interpret the practical too narrowly. While a rather extensive course seems to be demanded by the manifold applications of mechanics in engineering, his experience in the class-room emphasizes strongly the limitations imposed by restricted time and lack of maturity of students. It will scarcely be questioned that the matter of first importance to the student is a clear understanding of principles rather than an assortment of special rules for solving particular problems. The presentation of principles in a sound and intelligible manner should, therefore, be the chief aim of a text-book, and methods of presentation and illustrative examples should be chosen primarily with reference to this aim.

The success with which this requirement is met by the three books under review will be differently estimated by different teachers. Each possesses merit of a high order, and there is little room for adverse criticism except such as implies a fair difference of opinion as to what methods of treatment are to be regarded as best. It will here be attempted only to indicate the character and scope of each of the books, and to make some general observations regarding methods of presenting the principles of mechanics in an elementary text-book.

As a sound and practical text-book for the use of students of engineering Professor Maurer's book possesses high merit. The exposition is nearly always concise—indeed, this is perhaps often carried to a fault—but the soundness of the logic is rarely open to question. The author shows close sympathy with the point of view of the beginner, and appreciation of the fact that at certain points the conventional treatment of fundamental principles fails to meet the needs of the ordinary student.

Professor Ziwet's book is an excellent introduction to the science of analytical mechanics. His exposition is in general sound and logical, and the book will be read with pleasure and profit by a student of mathematical tastes and ability who has the requisite mathematical training. The maturity and mathematical equipment required for reading it at all easily appear to be greater than are possessed by most of those who take up the subject in the second or third year of the ordinary four-year course in engineering, but

the book will doubtless prove effective in the hands of a teacher who is in sympathy with the methods and point of view of its author.

Stephan's book is admirable for the simplicity with which elementary principles and methods are presented. If written in English it would probably find favor with many teachers in America who desire a text-book not presupposing calculus. It should be said, however, that while calculus notation is not employed by Stephan, he does employ the conceptions of both differential and integral calculus. The fundamental conceptions of the calculus are, of course, necessarily employed in any sound presentation of the principles of mechanics, and it may be doubted whether real simplicity is gained by avoiding its notation.

The three books are all designed for students of engineering, and each aims to be practical by including many numerical exercises and illustrative examples of the kind met in engineering practise, but each is a text-book of theoretical, rather than applied, mechanics. All have much the same scope, covering the statics, kinematics and kinetics of particles and of rigid bodies. Two of the books—those of Maurer and Stephan—agree somewhat closely in order of treatment, beginning with statics and following with kinematics and kinetics. Ziwet, on the other hand, begins with geometry of motion and kinematics, follows with an introduction to dynamics (statics being treated as a special case) and concludes with kinetics. In all the treatment is mainly restricted to the simpler force systems and the simpler cases of motion. Of the three books that of Stephan is the most elementary in treatment, while that of Ziwet would probably be the most difficult reading for the average student beginning the subject in its usual place in a course in engineering.

As features of Maurer's book may be mentioned the emphasis everywhere given to the vector nature of the quantities dealt with, the parallel treatment of graphical and analytical methods in statics, the admirable chapter on work and energy, and the satisfactory treatment of the subject of units. Professor Ziwet also gives prominence to vector notions, and also includes graphical methods in statics, though less fully than Maurer. His book contains no systematic presentation of the theory of energy, though the main features of the theory may be gathered from detached passages. His treatment of kinematics and kinetics is throughout more elaborate on the theoretical side than that of Maurer or of Stephan, and more use is made of general analytical methods. Stephan does not use the language of vectors. In statics he makes free use of graphical methods, but does not give the student the aid which comes from the use of Bow's notation for the designation of forces. His treatment of kinematics and of kinetics is relatively brief, and only the merest introduction to the theory of energy is given, potential energy not being mentioned.

Dimensional equations and the theory of units are explained by both Maurer and Ziwet, the former devoting to this subject an appendix of six pages. In Professor Ziwet's book (Art. 58) occurs an erroneous illustration which is likely to confuse the student: '* * * we have of course the proportion: 30 miles an hour is to one mile an hour as 44 feet per second is to one foot per second.' Both gravitational and kinetic systems of units are explained in each of the three books. The simple treatment of the engineers' kinetic system adopted by Maurer and Stephan should effectually clear away the traditional haziness surrounding the equation $m = W/g$. The unit mass is taken as a derived unit, and defined as the mass to which the gravitation unit force (the pound-force or kilogram-force) gives unit acceleration; this unit mass is thus equal to g pounds or g kilograms, and the equation expresses the reduction from one unit mass to another. The usefulness of a name for the unit thus defined will be agreed to even by those who hesitate to adopt the names *geepound* and *geekilogram* suggested by Maurer.

In considering the general question as to the best method of presenting the fundamental principles of mechanics in an elementary text-book, two requirements must be kept in view, soundness and intelligibility. Critics are by no means agreed as to what constitutes a sound formulation of the laws of motion.

Newton's laws have long held their place in the majority of English and American books, and in spite of the fact that the philosophical validity of the Newtonian system has been seriously questioned by able critics, this system, properly understood, still appears to furnish substantially the best foundation. It does not follow, however, that a literal translation of Newton's words is the best formulation of the laws of motion for the purpose of elementary instruction. That Newton's formulation is not easily understood by the beginner is tacitly recognized by most writers, much space being ordinarily devoted to explanations of the meaning of Newton's language. Without here attempting a full analysis, it may be profitable to suggest certain points in regard to which students may be aided by a departure from the usual method of stating and explaining the fundamental laws.

(1) Recognizing force as a fundamental quantity whose nature is known roughly, at least, from ordinary experience, its definition should be so stated as to include the fact that a force is exerted *by* a body. This should also be embodied in the statement of the first law, which might take the form 'a body uninfluenced by other bodies would move uniformly in a straight line or remain at rest.' It should also be embodied in the statement of the law of action and reaction: 'When one particle exerts a force upon another the latter exerts one upon the former, and the two forces are equal, collinear and opposite.'

(2) The full explanation of the second law should be preceded by a clear explanation of the meaning of acceleration as a vector quantity. The law itself might be stated as follows: 'A force acting alone upon a particle gives it an acceleration whose direction is that of the force and whose magnitude is proportional directly to that of the force and inversely to the mass of the particle.'

(3) The parallelogram law should receive explicit statement: 'Two forces acting simultaneously upon a particle give it an acceleration which is the vector sum of the accelerations which would be due to the forces acting separately.' 'Two forces acting simultaneously upon a particle are equivalent to a single force equal to their vector sum.' These statements are seen to be equivalent by virtue of the second law. An experimental statical proof of the parallelogram law is instructive, but its acceptance as an exact law rests on the same basis as that of the rest of the laws of motion—the apparent exact agreement of these laws with all experience.

Without entering into a detailed account of the treatment of the laws of motion in each of the three books under review, it is of interest to notice the different methods of defining and explaining force. Maurer's treatment is in close agreement with that here suggested; the point emphasized in (1) is explicitly stated at the outset, and the above statement of the law of action and reaction is in Maurer's words. Stephan gives the common but vague definition of force as the cause of a change of motion, the elementary but important fact that a force is always exerted by a body being explicitly stated only at the end of the three pages devoted to the preliminary explanation of force and of the law of action and reaction. In Ziwet's book the treatment of force oscillates between two different points of view. Force is defined mathematically as the product of the mass of a particle into its acceleration, and the author evidently agrees with those who regard force as a fiction, while he does not find it easy or advisable to discard the conception of force as a cause of motion in explanations addressed to beginners. The definition of force as the product of mass into acceleration, and the denial of force as a physical reality, are in harmony with what is, perhaps, the prevailing view among philosophical critics. Such a view is, however, wholly meaningless to the beginner, and it must be insisted that the treatment of force in an elementary text-book should build upon common notions and everyday experience.

Although, in an elementary text-book, logical rigor is not to be too strictly insisted upon, it is important to avoid false logic, and especially the appearance of logically proving what is really assumed. At certain points many current expositions of the principles of

mechanics appear to be open to criticism on the ground of false or defective logic.

Consider, for example, Stephan's treatment of the law of composition of forces, which is substantially identical with that found in many text-books. In Art. 69 is the statement: 'If several forces act simultaneously upon a particle, the acceleration which each force imparts to the particle is independent of the existing velocity and of the action of the other forces.' For the explanation of simultaneous accelerations and of the method of combining them reference is made to Art. 66. But this explanation relates to a particle having a certain motion with respect to one base of reference, while this base is itself in motion with respect to a second base, so that the two 'simultaneous accelerations' refer to different bases or axes of reference. This throws no light on what is meant by simultaneous accelerations of a particle when only a single base of reference is in question. In the composition of forces we are not concerned with moving axes,* and in the analysis of motion with respect to any single base it is only by an arbitrary use of language that a particle can be said to have at the same time two different accelerations. Its actual acceleration may, of course, be expressed as the vector sum of components, but this may be done arbitrarily and in any number of ways; in choosing a particular set of components and associating each with a force we are merely *assuming* the parallelogram of forces.

From a logical standpoint the treatment of the theory of energy is an unsatisfactory feature of many text-books. Commonly energy is defined as the 'capacity of a body to do work,' or as the 'quantity of work a body can do,' while the meaning of work as done by a body is nowhere explained, work being defined only as done by a force. Another logical defect is to make $\frac{1}{2}mv^2$ the definition of kinetic energy instead of proving from a general definition of energy that a particle possesses by virtue of its motion the quantity of energy $\frac{1}{2}mv^2$. Of the three books under review, that of Professor Maurer is the only one that includes a logical and systematic presentation of the theory of energy.

Although the discussion of questions of terminology often seems fruitless, it may be worth while to refer to certain of these because of their importance as affecting the acquirement of sound notions by the beginner. That there has been little progress toward general agreement in the use of such terms as stress, centrifugal force, inertia force, is unfortunately due in part at least to the fact that discussions over them have involved more than mere questions of terminology.

The word stress is too often used vaguely, without attempt at exact definition. Among writers whose usage is clear, two definitions are current, which were formulated by Rankine and by Maxwell respectively. Rankine defined as stresses the forces which the particles of a body exert upon one another to resist strain (*i. e.*, departure from the 'natural' configuration). By Maxwell the action and reaction between any two portions of matter was called stress.* The usage of engineers, so far as it is definite, usually conforms more or less closely to the former definition, while the latter has been adopted in a number of works on both theoretical and applied mechanics. There are reasons in favor of each of these definitions, but it is to be regretted that the writer of a text-book should depart from both. Professor Ziwet apparently uses stress to designate any pair of equal and opposite forces in the same line, whether constituting an action and reaction or not. This sacrifices the chief value of Maxwell's definition, which is that it keeps clearly before the mind the fact that every force has its reaction and that action and reaction act upon different

* It is worth while to emphasize the argument by remarking that the accelerations of a particle with respect to two different sets of axes are not related by a simple parallelogram law unless the relative motion of the two bases is a translation. A full logical analysis of the laws of motion, including the parallelogram law, must include a consideration of the meaning of absolute and relative motion—a question which may well be omitted from an elementary book and which will not be entered into here.

* See Rankine's 'Miscellaneous Scientific Papers,' p. 120; Maxwell's 'Matter and Motion,' Chapter III. It should be said that neither author used the word in a uniform sense throughout his writings.

portions of matter. One of the most common and vicious errors is that action and reaction are counterbalancing forces. This error will inevitably be made if stress is defined as action and reaction, and then used to designate a pair of counterbalancing forces. Professor Maurer's usage, while departing from both the above definitions, is clear and consistent. He defines stress as any force whose place of application is a surface.

Most present-day text-books, including the three before us, define centrifugal force as the reaction which a particle constrained to describe a curved path, or a rigid body constrained to rotate about a fixed axis, exerts upon the constraining body. This definition is clear, and would be satisfactory if it were not inconsistent with general usage in the only class of problems in which the term is really needed—*i. e.*, problems in which motion is referred to rotating axes. It is convenient in such cases to give the equation of motion of a particle the same form as if the axes were fixed, introducing such fictitious forces as would produce the accelerations actually due to the motion of the axes. One component of the fictitious force for each particle is the centrifugal force, which is thus not a reaction exerted by the particle but a force assumed to act upon it. This must be regarded as the legitimate use of the term centrifugal force. Inconsistency in the use of this term in elementary text-books is responsible for much confusion in the mind of the student. An example of this inconsistency occurs in Stephan's book, pp. 279, 281. Centrifugal force is defined as the reaction exerted by a particle upon the body which deflects it from a straight path. But in the discussion of the belt and pulley an element of the belt is said to 'experience' a centrifugal force.

So much confusion of thought has been shown in discussions of 'inertia-force' that it seems desirable to drop the term entirely. Those who use it often appeal to the authority of Newton; but it is well known that Newton did not restrict the word force to its present specialized meaning, and that which he meant by force of inertia is not force at all in the present meaning of the word. Professor Ziwet defines force of inertia of a particle as the reversed effective force, *i. e.*, a force $-mj$, m being the mass of the particle and j its acceleration; and he explains that this force is exerted not on the particle but by it, being the reaction to the force which acts upon the particle to produce its acceleration. A student who compares this statement with the following (p. 160) is likely to be somewhat bewildered: "The fact that any change of motion in a physical body is affected by its mass is sometimes ascribed to the so-called 'inertia,' or 'force of inertia,' of matter, which means, however, nothing else but the property of possessing mass." This latter statement is practically Newton's explanation of force of inertia.

The preceding definition (also given by Stephan) is sanctioned by various writers of high authority. It may, however, be doubted whether there is any real need of a term to designate the reversed effective force $-mj$; at all events the term inertia-force used in this sense seems inappropriate and misleading. The nature of the action to which we give the name force does not depend upon whether the body exerting it has or has not acceleration. Suppose, for example, that a particle is acted upon by two bodies only, A exerting a force P upon it and B a force Q, and let R be the vector sum of P and Q. The particle reacts upon A with a force $-P$ and upon B with a force $-Q$; there is no body upon which it exerts a force $-mj=-R$. The 'inertia-force' is thus merely the vector sum of two forces exerted by the particle upon different bodies. There is nothing peculiar about these forces, and no reason why either of them should be attributed to the 'inertia' of the body. If P and Q become equal and opposite, the so-called inertia-force becomes zero, but the nature of the forces P and Q and of the reactions to them is unchanged. Neither is the nature of P or of its reaction changed if Q ceases to act; there is no more reason in this case than in the preceding for attributing the force exerted upon A to the inertia of the particle.

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SCIENTIFIC JOURNALS AND ARTICLES.

THE November-December number of *The Journal of Geology,* which is the final one of Vol. XII., contains as the leading article Professor Wm. M. Davis's address before the Department of Earth Sciences in the World's Congress of Science and Arts at St. Louis on 'The Relations of the Earth Sciences in View of their Progress in the Nineteenth Century.' Dr. S. W. Williston contributes a 'Notice of Some New Reptiles from the Upper Trias of Wyoming' which were secured by the University of Chicago paleontological expedition of last summer. Four new genera and species are described. Messrs. S. R. Capps and E. D. K. Leffingwell describe the 'Pleistocene Geology of the Sawatch Range, near Leadville, Colo.' Professor Rollin D. Salisbury describes 'Three New Physiographic Terms' which are topographic unconformity, topographic adjustment and superimposed youth. O. W. Wilcox has an article 'On Certain Aspects of the Loess of Southwestern Iowa' and Miss I. H. Ogilvie describes 'The Effect of Superglacial Débris on the Advance and Retreat of some Canadian Glaciers.' The conclusion is 'that the débris covering, and that alone, is responsible for the advance, and indeed for the continued existence, of the glaciers of the eastern Rockies.'

The American Geologist for January contains a 'Biographical Notice of William Henry Pettee' with plate by Professor Israel C. Russell. Mr. George F. Becker's address before the Geophysical Section at the International Congress of Arts and Science at St. Louis on the 'Present Problems of Geophysics' is published. Professor J. F. Whiteaves contributes an article entitled 'Notes on the Apical End of the Siphuncle in some Canadian Endoceratidæ, with Description of Two Supposed new Species of Nanno,' which is illustrated by two plates. 'The Progress of Vertebrate Paleontology at the American Museum of Natural History, New York,' is reported by Mr. O. P. Hay. 'The Comparative Accuracy of the Methods for Determining the Percentages of the Several Components of an Igneous Rock' is discussed by Mr. Ira A. Williams. Mr. W. C. Morgan considers 'The Origin of Bitumen,' and from the discovery of a fossil egg partly filled with asphalt concludes that 'natural conditions are thus demonstrated to be sufficient to transform animal matter into bitumen during long periods of time without the aid of heat.' There are also given abstracts of papers presented at the Philadelphia meeting of the Geological Society of America by Professors Cumings, Tarr and Willis and Mr. Fuller.

The Popular Science Monthly for February contains the following articles: 'An Address on Astrophysics,' W. W. Campbell; 'The Metric System of Weights and Measures,' E. A. Kennelly; 'A Botanical Laboratory in the Desert,' Francis E. Lloyd; 'How Immigrants are Inspected,' Allan McLaughlin; 'On the Relations of the Land and Fresh-Water Mollusk-Fauna of Alaska and Eastern Siberia,' William Healey Dall; 'Examinations, Grades and Credits,' J. McKeen Cattell. In 'The Progress of Science' are to be found accounts of 'Convocation Week,' 'The American Association,' with portraits of the vice-presidents, 'The Presidential Address' and 'The Affiliated Societies.'

Bird-Lore for January-February has 'A New Year's Suggestion' on nesting trays for robins, by Mabel Osgood Wright; 'Nesting Boxes'—illustrated—by E. H. Forbush; Nest-Box Suggestions; 'On the Construction of Houses for the Purple Martins,' J. Warren Jacobs; and Nest-Box Notes. There is *Bird-Lore's* Fifth Christmas Bird Census and the eighth paper on 'The Migration of Warblers' by W. W. Cooke. The number contains the Report of the National Association of Audubon Societies, which includes a History of the Audubon Movement, Report of the National Committee for 1904 and the State Reports.

The American Museum Journal for January bears the subtitle Fossil-Carnivore Number, over one half its sixty pages being devoted to a synopsis of fossil carnivores, marsupials and small mammals in the American Museum of Natural History. The article, which is by W. D. Matthew, is well illustrated and accompanied by a list of important books of reference. The number contains a description of 'The Cape York Meteorites,'

notes on the additions in various departments and lists of the various lecture courses.

SOCIETIES AND ACADEMIES.

THE NEW YORK ACADEMY OF SCIENCES. SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

THE regular monthly meeting of the section was held at Fayerweather Hall, Columbia University, on Monday evening, November 7, with Professor Charles L. Poor in the chair. Abstracts of the papers which were presented before the section are as follows:

The Relation of Kathode Resistance to the So-called Saturation Current in the Discharge through Gases: F. L. TUFTS.

In this paper it was pointed out that the so-called saturation currents obtained by Wilson and other investigators of the phenomena of electrical conduction through flame gases were not true saturation currents, but only apparently so, owing to the development at the kathode of a high resistance when the impressed electromotive forces were over a few volts. By the use of a kathode coated with calcium oxide and heated by a separate flame it was shown that the resistance of a flame connecting this with the anode remained practically constant; that is, the current through the connecting flame increased directly as the potential gradient for gradients ranging from a few tenths of a volt to the centimeter, up to gradients of as much as fifty volts to the centimeter.

Experiments were made with the ordinary luminous gas flame as well as with flames rendered non-luminous by the admixture of air, and the relation between current and potential gradient was found to be the same for both kinds of flames.

The Duration of the Afterglow Accompanying the Electrodeless Discharge at Low Pressures, Effect of Temperature: C. C. TROWBRIDGE.

The purpose of the investigation was to determine the nature of the glow that often appears after the cessation of the electrodeless discharge in gases at low pressures. Measurements made thus far on the duration of the glow in air show a sharp maximum of duration between .1 and .05 millimeter pressures and that this maximum point varies with the electrical conditions of the experiment. It was also determined that there is a critical point between .7 and .3 millimeter pressures where the glow is only occasionally formed, after which as the pressure is further reduced, the duration of the glow increases rapidly to the maximum. The electrodeless discharge was also made to take place at liquid air temperature and it was found that the afterglow accompanying the discharge was diminished considerably in duration and intensity at the low temperature of about — 186° C.

The officers of this section for 1905 were then elected and are as follows:

Chairman—Ernest R. van Nordroff.
Secretary—Charles C. Trowbridge.

THE next regular meeting of the section was held on Monday, December 5, with Professor William Hallock in the chair in the absence of Professor Poor.

The papers of the evening were as follows:

The Combination of Ions with the Solvent in Solutions: C. W. KANOLT.

The object of Dr. Kanolt's investigation was to determine whether or not the ions of a salt in solution are combined with the solvent. The method used was the electrolysis of a salt dissolved in a mixture of two solvents, with the subsequent analysis of the portions of the solution around the two electrodes. If the ions are combined with either of the solvents, this solvent will be carried from one electrode to the other, and changes in the proportions of the two solvents are to be expected. Positive results were obtained with silver nitrate dissolved in a mixture of pyridine and water, indicating that pyridine was combined with the silver ions. With the same salt in a mixture of alcohol and water only negative results have so far been obtained. Other salts are being investigated.

Chemical Combination of Knall-gas under the Action of Radium: BERGEN DAVIS and C. W. EDWARDS.

The experiments described relate to the chemical combination of hydrogen and oxygen

under the action of radium rays. The gases were enclosed in a vessel in such a way that a small change of pressure could be observed. About four milligrams of radium bromide were dissolved in alcohol and deposited on the surface of a small sheet of platinum which was placed in the vessel.

By means of electrodes the amount of ionization produced in the gas by the radium was measured. While the rate of formation of water was quite slow, yet the number of molecules of water formed for each physical ion produced was very large. The experiments are being continued by Professor Edwards.

C. C. TROWBRIDGE,
Secretary.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

AT the 593d regular meeting, the 34th annual meeting, held December 24, 1904, the following officers were elected:

President—G. W. Littlehales.

Vice-Presidents—Cleveland Abbe, J. G. Hagen, A. L. Day, L. A. Bauer.

Treasurer—Bernard R. Green.

Secretaries—Charles K. Wead, Lyman J. Briggs.

General Committee, besides those named above—W. A. De Cundry, H. M. Paul, J. Winston, L. A. Fischer, R. A. Harris, E. B. Rosa, C. G. Abbott, K. E. Guthe, W. S. Eichelberger.

The secretaries' and treasurer's reports showed that the society is in a prosperous condition, having had a considerable increase of membership during the past year.

THE 594th regular meeting was held January 7, 1905.

The first paper was by Mr. E. P. Hyde, of the Bureau of Standards, by invitation, on 'Some Problems of Photometry.' These related mainly to the rating of electric incandescent lamps, and to practical methods of obtaining the mean spherical illumination applicable to the various forms of lamps with their widely differing filaments and distribution curves. In the Matthews photometer there are a number of pairs of mirrors, the centers of one set lying in a meridian of the lamp and throwing the rays to the mirrors of the other set, whence they go to the screen. The lamp is rotated about 180 times per second. The speaker had determined the angular position of the mirrors of the first set that would give theoretically accurate results for three extreme cases of distribution, and then found an average position that reduces materially the small errors of the Matthews instrument.

Mr. W. J. Spillman, in charge of the forage plant investigations of the Department of Agriculture, then spoke on 'Utilizing the Desert,' dealing with the cactus and its uses, and showing many slides.

It has been found that the cactus plant possesses considerable value as feed for cattle, sheep and hogs. It is universally used by Mexican freighters in southwest Texas for their work oxen, and in famine years it is used by stockmen generally to tide over the dry periods, and for this purpose it possesses great value. The possibility of utilizing cactus frequently saves the wiping out of vast herds of cattle in time of famine. Several methods are in vogue for getting rid of the spines preparatory to feeding cactus. One of the most common is to scorch off the spines over a brush fire. A modification of the plumbers' torch is more or less extensively used for treating cactus in place. Many stockmen use a specially constructed cutting machine which pulps the cactus and abrades the spines so that the juices of the plant quickly render the spines innocuous. The pulped material is readily eaten. Some steam the cactus in large vats, which so softens the spines that they become harmless. Some varieties of cactus will thrive with one rain a year; and averaging a period of years an acre of cactus is equal to an acre of ordinary forage plants.

AT the 595th meeting, January 21, 1905, Dr. Guthe exhibited a bar of Heusner's alloy composed of 60 per cent. copper, 27 per cent. manganese and 13 per cent. aluminum, which is strongly magnetic, though none of its constituents is so.

Mr. Abbott exhibited and described 'A Comparator with Planimeter Attachment' especially devised for reading ordinates, abscissæ and areas of curves on 10-inch by 24-inch

photographic plates. In connection with the spectrobolographic determinations of the solar constant of radiation at the Smithsonian Observatory, it is desired to know the variations in ordinates of bolographic curves corresponding with the intensity of rays of different wave-lengths in the solar spectrum, and further to sum up the areas included under such curves corresponding to the total energy of radiation reaching the bolometer.

The machine shown was constructed after Mr. Abbott's general design by Warner & Swasey, and consists, like the ordinary comparator, of a microscope moved by screws in ordinates and abscissæ, but this is here combined with a cone and rolling disk. The disk moves horizontally along the elements of the cone as governed directly by the position of the microscope in ordinates, while the number of revolutions of the cone is proportional to the motion of the microscope in abscissæ. Accordingly the number of rotations of the disk is proportional to products of ordinates and abscissæ, and by passing along the contour of the curve between given abscissæ, and back over the zero line to the original starting point, the difference in reading of the disk counter yields the area.

As constructed, the machine is best suited to areas of more than ten square centimeters, but a smaller machine would doubtless be equally successful. The accuracy of measurement actually reached with the instrument shown is 0.1 square centimeter, and numerous measurements of circles and other areas to this degree of accuracy were cited.

Mr. F. E. Fowle, Jr., also of the Smithsonian Observatory, then discussed 'The Discrepancy between Solar-Constant Measures by the Actinometer and by the Spectro-Bolometer.' He referred to Mr. Langley's proof that actinometric extrapolation by Bouguer's formula gives necessarily too low values for the extra-atmospheric solar radiation. It is, however, found by comparison with spectrobolometric determinations that the discrepancy is nearly constant and is about 14 per cent. for such atmospheric conditions as exist at Washington, when Ångstrom's actinometer is used.

Further refinements to the correction may later be determined as functions of the slope of the actinometer curve, the humidity and the air masses serving for the extrapolation.

Charles K. Wead,
Secretary.

THE BIOLOGICAL SOCIETY OF WASHINGTON.

The 395th regular meeting was held at the Assembly Hall of the Cosmos Club on January 14, 1905, with President Knowlton in the chair and forty-six persons present.

Dr. A. D. Hopkins showed specimens of what are undoubtedly fossil borings, probably by some beetle of the family Cerambycidæ.

Professor W. P. Hay renewed a discussion from a previous meeting, and stated that proper credit is given in the scientific world to Cæsalpinus for the discovery of what we commonly know as the circulation of the blood.

Mr. C. O. Townsend presented a paper on the 'Distribution and Development of the Sugar Beet Industry,' in which he called attention to the difference between the sugar beet and the beet sugar industries. Of the latter he illustrated by lantern slides some of the largest beet sugar factories, the largest being in southern California. He then showed a very instructive series of slides dealing with the sowing, cultivation, harvesting and shipping of the sugar beet crop, including views of the workers employed, machinery used and results gained.

Mr. A. C. Veatch discussed 'The Question of Origin of the Natural Mounds of Louisiana, Arkansas and Texas' (illustrated with photographs). Of the many theories of origin suggested for these mounds three deserve the most careful attention: (1) the spring and gas vent theory, (2) the dune theory, and (3) the ant hill theory.

In the spring and gas vent theory it is argued that the gas produced by the decay of the large amount of vegetable matter buried in the coastal plain strata has, with the artesian water associated with it, brought to the surface fine sand and built up low cones. Small cones are now forming in this manner at many points in the coastal plain, and they

were pointed to as proving this hypothesis. The fatal objection to this theory is that entirely identical mounds are found in Indian Territory on flat plains underlaid by higher inclined carboniferous shales and sandstones, where the substructure clearly lacks the elements required by this hypothesis.

The dune theory is based on the resemblance of these mounds to the low dunes which collect in the semi-arid region of the west about clumps of low vegetation. The objection to this theory is the great irregularity of wind-made features and the very notable uniformity in size and exact resemblance, one to another, of these natural mounds of the south central United States over an area at least 300 miles wide and 500 miles long. It would seem that in so large an area a wind origin would involve a greater variation in size than has been observed, and necessitate the presence of occasional dunes, or lines of dunes, of noteworthy size, whose origin could not, in any way, be doubted.

In the ant hill theory two possible lines of development were suggested: (1) that the mounds are the work of the atta, or leaf-cutting ants, (2) that they are the remains of hills of the mound-building variety of white ants, the termites. According to Professor W. M. Wheeler, atta hills in western Texas reach a diameter of forty to fifty feet and height of one to two feet; and Mr. E. A. Schwarz, of the National Museum, reports that the atta hills in Cuba often reach a height of ten to twelve feet and a diameter several times as great. These occurrences add greatly to the possibility of an ant origin.

Regarded as the work of mound-building termites, which are now restricted to the tropical regions, these mounds suggest a warmer and moister climate. Modifications such as those which permitted large elephants, camels and animals of the sloth and armadillo families to live in this region would also have permitted these, now similarly restricted mound-building termites, to do the same; and the causes which resulted in the extinction of the larger animals would also, though at a later date, have destroyed the mound-building termites.

Of the theories of origin yet suggested none are entirely satisfactory, and the dune and ant hill theories are the only ones well supported. If either of these hypotheses is correct the mounds are indications of important climatic changes in very recent time. It was suggested that the matter should be approached by the careful excavation of a number of these mounds at widely different points in order to fully determine the relation of the mounds to the beds which underlie them and to the soil surrounding them.

The last paper of the evening was by Mr. A. S. Hitchcock on 'The Twigs of Woody Plants with Deciduous Tips.' Woody plants in our latitude ordinarily form well defined winter buds at the time of elongation of the season's growth in late spring or early summer. Such growth is often referred to as definite or determinate. In some plants such as the willow the growth of the twigs continues during the season and is retarded and finally stopped by the advent of winter. Some plants have the habit of casting or sloughing off the terminal portion of the young twig at a definite point much as a leaf is cast in autumn. Such twigs present a scar at the end and, instead of a terminal bud, as in hickories or walnuts, the uppermost lateral bud continues the growth of the stem. Examples of this method are the elms, basswood and many other woody plants with two-ranked leaves. The tip of the twig is usually cast in the summer when the buds are formed. The speaker called attention especially to the twigs of the common sumac (*Rhus glabra*) gathered in December which showed remarkably long terminal portions of the twigs still attached but with the well-defined delimiting layer separating the healthy ripened wood from the dead terminal portion (five or six inches) which would be cast off during the winter.

E. L. MORRIS,
Recording Secretary.

THE ONONDAGA ACADEMY OF SCIENCE.

THE Onondaga Academy of Science held its January meeting in Lincoln Hall of the high school building, at Syracuse, on the evening of the twentieth. Dr. John M. Clarke

delivered an able address on the subject, 'Niagara Falls of the Future.'

The speaker, disclaiming any purpose of antagonizing the splendid industrial development at Niagara, invited attention to the paramount claim of the world to this famous spot as against the commercial claim which threatens to convert it into dollars, and by so doing make an end of the American Falls. The recent comment of Lord Kelvin, that the falls would have to be absorbed to meet industrial demand, was criticized as the expression of the sterile sentiment which has permitted the destruction of the classic Falls of Lodore and has already half ruined the Falls of Montmorency. The speaker insisted that industrial progress must leave something to the higher life, to the play of the finer emotions, and from such a view point no justification or compensation can be found for the destruction of such a stupendous display of nature's power.

Though it seems to the casual observer that nothing man can do could abate the enormous volume of waters descending in this cataract, and accomplished hydraulic engineers have been known to deride the possibility that the falls would be injured, yet the menace to the perpetuity of the American Falls is immediate and imminent. The volume of water descending at Niagara has been measured on several occasions with slightly divergent results giving as an average which has been accepted in the calculations of the engineers 224,000 cubic feet per second. This falling an average of 150 feet is equivalent to a potential horse-power of 3,800,000, not of between five and six millions as is constantly stated in the estimates and reports of the engineers.

The legislature of New York has chartered nine companies for the development of power at this place, all but two to take water from above the falls and return it below, one of these two proposing not to return it to the river at all, but to carry it to Lake Ontario by another passage, the other purposing to take advantage alone of the fall in the gorge below the cataract. Of these nine companies, no one of which is required to pay a francise to the state for its tremendously valuable privileges and some of which are permitted to take unlimited water for their purposes, but two are now actively producing power, and it is believed that but one other is now preparing to do so. The two producing companies are limited by law in the amount of water they may consume, the last named is not. The producing companies are far within their limitations at the present, but in both the waste of water and of power is appalling. The series of small cataracts which cover the American bank just below the steel arch bridge, which are the waste discharges from the power canals and the unused fall of the power tunnel which discharges near the same spot, indicate that but a fraction of the potential power of the water now taken from the American river is utilized. The salvage of this wasted power, however, has begun, and its utilization will be continued by the building of factories along the edge of the water beneath the cliff. To save the wasting power of these companies the place must be even worse disfigured than it is at present.

The Canadian companies, three in number, have now in part completed their installment; in so doing, however, they have taken from the river great sections of the stream for their forebays and permanent construction. These companies when working will pay a substantial annual return to the commissioners of the Queen Victoria Park.

The immediately contemplated abstraction of water by the six active companies is:

	Cu. ft. per Second
Two American companies	16,300
Three Canadian companies	32,100
	48,400
It is estimated that the third active American company will consume	10,000
	58,400
The Canadian engineers have proposed four additional power works with a total abstraction of water of	29,996
	88,396

The following abstractions from this drainage basin are assumed as constants and are not here taken into consideration.

Chicago drainage canal	6,000
Proposed barge canal	1,200
Welland canal	600
	7,800

It is a matter of measurement that but one fourth of the water in the Niagara River passes over the American Falls. The sill of the falls is ten feet higher on the American side than on the Canadian. How easily the water is driven entirely out of the American channel is seen by the ice dams of the past few years, which, gorging the stream from the upper end of Goat Island to the American side, have turned the water from that channel so that one can cross the bed of the river dry-shod. Let then, from one fourth to one third of the water be permanently abstracted from the river, and the American Falls will be permanently dry. The production of power actual and immediately contemplated by the five companies within their charters will consume 48,400/224,000 of the water, or 1/5 —. With the estimated abstraction of water by the sixth (American) company this fraction becomes 58,400/224,000 or 1/4 —. Should the proposed additional Canadian plans be effected the proportion will become 88,396/224,000 or 1/3 —. In any one of these cases the danger limit is reached and the perpetuity of the American Falls now hangs by the slender thread of improbability that these companies shall produce to their statutory limitations or find a market for their product.

It is authentically stated that 800,000 tourists visit Niagara annually, bringing an enormous revenue to the place. As soon as the world learns that New York and Canada have shorn this famous place of its beauties, this source of industrial prosperity will be gone. While these magnificent schemes of power development are putting to shame a sentiment of proper pride which should be national rather than local, unlimited horsepower lies idle in the region where these companies hope to find their market and in the development of this none of the finer manifestations of natural power and none of the finer sentiments of mankind would be assailed.

The address was a strong presentation of the subject and the press of the city joined in the protest against the destruction of the falls.

J. E. KIRKWOOD,
Corresponding Secretary.

DISCUSSION AND CORRESPONDENCE.

CONSULTING EXPERTS IN LIBRARIES.

TO THE EDITOR OF SCIENCE: Dr. Francis B. Sumner's letter, published in SCIENCE, January 13, seems to offer an appropriate opportunity for calling attention to certain noteworthy developments at the Library of Congress during the administration of Dr. Herbert Putnam. Dr. Sumner urges the desirability of employing, in connection with one of our great libraries, 'a staff of consulting experts, men of the rank of college professors, whose duty it should be to furnish definite bits of information in response to legitimate questions, or, at least, to guide the seeker on his way * * * the establishment of a sort of human encyclopedia as an adjunct to the library.'

While this ideal has not yet been attained at the Library of Congress, a remarkable development in this direction has taken place during the last few years. It is the function of the Division of Bibliography, established in 1900, not only to prepare and publish lists of references on special topics, principally those of current political interest, but also to supply bibliographical information in reply to inquiries received by mail. The reference work of this character has been mainly in the fields of social and political science and history.

As, however, the collection of scientific literature has recently been reclassified and is now in process of being recatalogued, it has become possible to undertake similar work in science. There are on the staff of the library at the present time several specialists representing different sciences, and it is always possible to consult others associated with various branches of the government service. Furthermore, it being part of the policy of the Librarian of Congress to make the collection of bibliographies, indexes, library catalogues, etc., as complete as possible, unusual resources in the way of bibliographical tools are available at the library. A Science Section of the library, in charge of the undersigned, has accordingly been organized recently and one of its functions is to carry on the reference work in this field, both for investigators at the scientific bureaus in Wash-

ington and in answer to legitimate inquiries by mail.

Under these circumstances it seems that the facilities now offered by the Library of Congress meet the need indicated in Dr. Sumner's letter to a very considerable extent, and further advances in this direction will occur if it appears that valuable service can be rendered.

I conclude by inviting the readers of SCIENCE to make use of these new facilities whenever the library resources to which they have access are inadequate to the needs of the investigations which they have in hand. Communications should be addressed to the Librarian of Congress, and should be marked 'Science Section' if they are inquiries referring to the mathematical, physical or natural sciences.

J. DAVID THOMPSON.

THE STORAGE OF MICROSCOPIC SLIDES.

TO THE EDITOR OF SCIENCE: In your issue of December 30 you published an article by C. L. Marlatt, of the U. S. Department of Agriculture, describing a method of storing and indexing microscopic slides.

The Bausch and Lomb Optical Company have designed and are selling an excellent cabinet with card system which has all the advantages claimed by Mr. Marlatt for his and lacking only the envelopes, which I can not but think must be somewhat inconvenient.

These cabinets are made in three sizes, holding 500, 1,500 and 3,000 slides respectively. Tiers of trays, each running in its own groove, are constructed to take slides of various sizes. At the bottom are drawers (one, two or three) containing separate cards for every slide, on each of which is printed a form for registering the slide: Tray No.—Series No.—Name of Slide—Stain—Mounted in— and two lines for other data. There are also printed guide cards from A to Z.

The objects being recorded on separate cards, the removal of slides necessitates simply the removal of its corresponding card, while the addition of slides requires only the filling out and insertion of new cards. Classification thus, it will be seen, becomes exceedingly simple. The slides may be rearranged and the collection increased or diminished with the least possible amount of trouble.

JOSEPHINE SHATZ.

ROCHESTER, N. Y.,
January 8, 1905.

SPECIAL ARTICLES.

DOPPLER'S PRINCIPLE AND LIGHT-BEATS.

THERE is a beautiful lecture experiment in illustration of Doppler's principle due, I believe, to Koenig. A vibrating tuning fork of high pitch, say 2,000 vibrations per second, is moved to and fro near, and at right angles to, a reflecting wall. The waves coming from the fork and (virtually) from its image back of the wall are changed in length by the opposite motions of fork and image with the result that very audible beats are heard. With a fork of the pitch mentioned, a speed of three feet per second gives beats at the rate of about eleven per second. Although special forks are made for this experiment, they are quite unnecessary. An ordinary C 512 fork of Koenig's pattern gives a very shrill tone when strongly bowed near the shank and answers the purpose admirably. If the fork is held stationary and the reflecting surface is moved, the effect is the same on account of the motion of the fork's image.

Attempts to secure visible beats by means of light waves of slightly different wave-length have met with no success, partly on account of rapid changes of phase, and partly because of the difficulty of securing two sources whose vibration frequencies are nearly enough equal. Thus if we assume (what is most likely not true) that the failure to observe interference fringes with differences of path greater than, say, 30 cm. indicates a change of phase, this would indicate 10^9 or more changes of phase per second. On the other hand, should we take the two D lines as sources there would be about 10^{12} beats per second. It is evidently almost hopeless to attempt to secure visible light-beats in this manner. If we consider Doppler's effect, however, the case is quite otherwise. The second form of Koenig's experiment, viz., that in which the reflector is moved, is in principle almost exactly analogous to Professor Michelson's interferometer.

In this instrument the alternations in brightness at any point in the field when the slide is moved are beats due to the Doppler effect just as truly as are those heard in the second form of Koenig's experiment.

ALBERT B. PORTER.

CHICAGO,
January 14, 1905.

NOTE ON THE BROAD WHITE FISH.

IN the *Proceedings* of the American Philosophical Society of Philadelphia, XLIII., 1904, p. 451, plates VIII. and IX., I have wrongly identified the broad white fish, or *Coregonus kennicotti* Jordan and Gilbert, as the humpback, or *Coregonus nelsonii* Bean. My error was due largely to lack of material, ignorance of the species from autopsy, and the fact, as I have since discovered, that *C. nelsonii* does not always exhibit the well-developed hump like that of the type. Possibly when the Siberian forms are carefully studied the nomenclatures of these fishes will be more stable.

HENRY W. FOWLER.

ACADEMY OF NATURAL SCIENCES,
PHILADELPHIA, February 5, 1905.

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*RECENT ZOOPALEONTOLOGY.**

DURING the past thirteen years great advances have been made in our knowledge of the ancient mammalian life of North America, especially through the explorations in the Rocky Mountain region carried on by the Carnegie, Field Columbian and American Natural History Museums. The long Tertiary period has been clearly subdivided into a series of stages and substages. This enables paleontologists to record more accurately than ever before the time of arrival and departure of the larger and smaller quadrupeds from North and South America, Asia, Europe, Africa, and to determine more precisely when the connection of North and South America was interrupted by a gulf flowing between the Atlantic and Pacific Oceans, and when the connection was again made by the elevation of the Isthmus of Panama; this demonstrates also that a very much closer connection existed between the animal life of Europe and of North America through continuous intermigration over the broad land area now submerged beneath the Behring Straits. A series of six world maps prepared by Dr. W. D. Matthew clearly exhibit this submergence and emergence of the isthmuses between these great continents.

Of especial interest is the recent discovery by the Geological Survey of Egypt that the whole race of mastodons and elephants originated in Africa, entered Europe in the middle of the Tertiary and soon afterward found their way into North America and somewhat later into South America. We have now been able to fix very positively the date of actual arrival of these animals in North America. It appears probable that successive waves of migrations of European and Asiatic species of elephants and mammoths came to this country. In the meantime there survived here from one of the earliest African migrants the eastern American forest mastodon which lived until comparatively recent times.

The theory of multiple races or polyphyletic evolution not only of elephants but of horses, rhinoceroses, camels and titanotheres appears to be clearly established through these recent discoveries. It was formerly believed, for example, that the modern horse had a single line of ancestors extending back into the Eocene period; now it appears that in North America there were always four to six entirely different varieties of the horse family living contemporaneously, including slow-moving, forest-living horses with broader feet, and very swift plains-living horses with narrow feet fashioned more like the deer. Intermediate between these arose the variety which survived and gave rise to the true modern horse. Furthermore, it appears that the modern horses separated from the asses and zebras at a much more remote period than has been generally supposed, and we are now endeavoring to ascertain accurately when this separation occurred.

The same discovery of multiple races has been made among the rhinoceroses. In Eu-

* Abstract of a lecture delivered by Professor Osborn before the Society of Naturalists at the Philadelphia meeting.

rope and in North America instead of forming a single line of evolution there were at least seven or eight nearly contemporary but distinct lines of rhinoceros succession, some of which can be traced back as far as the base of the middle Tertiary. The truly American rhinoceroses which appear to have branched out into several water-living, forest-living and plains-living types, were reinforced by the sudden appearance of the extremely short-limbed rhinoceroses which had evolved in Europe and came over to this country simultaneously with the earliest elephants or mastodons.

Another remarkable feature of this law of multiple evolution is that even where these varieties have evolved quite separately and independently, they still have inherited from remote common ancestors certain tendencies or potentialities of evolution which were latent but not expressed in the ancestral forms but which find a more or less simultaneous expression in the derived forms. Thus, among the rhinoceroses and titanotheres the rudiments of horns begin to appear more or less simultaneously in several of these multiple independent races or varieties, indicating a hereditary predisposition toward the development of certain organs quite unsuspected in the earlier evolutionary writings of Lamarck and Darwin. This predisposition to evolve certain structures tends to establish the idea that the laws of development are not controlled *solely* by the survival of the fittest as according to the original Darwinian theory, nor by the inherited effects of use and disuse as according to the Lamack-Spencer theory, but represent the budding out or expression of certain innate or inherited ancestral tendencies.

Among the greatest surprises in recent discovery has been the finding of armadillo-like edentates in the Rocky Mountain region near Ft. Bridger, Wyo., from rocks of the lower Tertiary period. These armadillos certainly bore a leathery if not a bony shield. Some ossicles indicating the presence of the bony shield are reported to be present in the collections of the Yale Museum; the remains thus far found by the American Museum exploring parties show a provision for the shield in the structure of the backbone but do not exhibit the bony elements of the shield itself.

Almost equally surprising results of ten years' exploration are the tracing back of the dog family into the Lower Eocene, of the saber-tooth tiger family into the Middle Eocene, of the camel family into the Upper Eocene, of the hedge-hogs (now extinct in this country) into the Lower Oligocene, of the raccoons into the Lower Miocene. The camel family, like the horses and the rhinoceroses, branched out into a great many varieties, short- and long-limbed, most remarkable among the latter being the giraffe-camel (*Alticamelus*), which, although a true camel, was closely similar in build to the giraffe. With these discoveries the names of Scott, Wortman and Matthew are honorably associated.

It has long been known that the deer, bear, moose, the oxen and sheep families did not appear in this country until very late in geological times, shortly before the Ice Age.

Among the many difficult and still unsolved problems is the cause of the total extinction of the horse in North and South America while it survived and multiplied in Europe, Asia and Africa. Just before the time of the extinction of the horse, America exhibited the greatest beauty and variety in the development of this family. As studied by Gidley, there were horses exceeding in size the enormous Percherons of to-day and there were also varieties smaller than the most diminutive Shetlands. Yet with all this wide range of variation all became extinct.

The elephants also exhibited three great varieties, the true mammoth (*E. primigenius*) to the north, the Columbian elephant in the central states, and the gigantic Imperial mammoth to the south, forms shown to be quite distinct by Lucas and undoubtedly adapted to various kinds of climate; yet all died out with the great wave of death which swept off the camels, horses and the giant South American sloths, just before or during the first advance of the Glacial period. H. F. O.

SCIENTIFIC NOTES AND NEWS.

The senate of the University of Edinburgh has voted to confer its honorary doctorate of

laws on Dr. Alexander Graham Bell, of Washington, and on Dr. W. W. Keen, professor of surgery at Jefferson Medical College, Philadelphia.

DR. S. WEIR MITCHELL, the eminent physiologist, physician and author, celebrated his seventy-fifth birthday on February 15. Dr. Weir Mitchell will present candidates for honorary degrees at the celebration of the University of Pennsylvania on February 22. Degrees will be conferred on President Roosevelt and on the Emperor of Germany.

ON the occasion of the opening of the new public health laboratory of the Victoria University, Manchester, honorary doctorates of science were conferred upon Professor Calmette, Lille University; Professor Perroncito, Turin University; Professor Salomonsen, Copenhagen University, and Captain R. F. Scott, R.N.

PROFESSOR K. MÖBIUS has retired from the directorship of the Berlin Museum of Natural History. The position has been offered to Professor H. H. Schauinsland, director of the museum at Bremen.

DR. FRIEDRICH PAULSEN, professor of philosophy at Berlin and known also for his works on education, will lecture at Harvard University during the first half of next year in accordance with the plan for an exchange of professors. As already noted, Professor Francis G. Peabody will lecture at Berlin.

VICE-ADMIRAL HUMAN has been elected president of the French Society of Geography.

DR. GEORGE BRUCE HALSTED has been made foreign associate and honorary professor of mathematics in the popular university of Tempio, Italy, and a fellow of the Royal Astronomical Society.

'THE Relation of Graduate Study to General Culture' was the subject of a lecture, given on February 3, at the University of Chicago, by Professor Josiah Royce, of Harvard University.

A CONFERENCE on school hygiene, arranged by the Royal Sanitary Institute, was held in the University of London, under the presidency of Sir Arthur W. Rücker, on February 7–10.

DR. MURGOCI, professor of geology at Bucharest, is carrying on research work in California.

DR. BURTON E. LIVINGSTON, of the department of botany of the University of Chicago, has been appointed to the staff of the Bureau of Soils in the United States Department of Agriculture, and will begin his new work at the close of the winter quarter.

DR. D. T. MACDOUGAL has started on an expedition to lower Colorado and the upper portion of California to collect botanical specimens for the New York Botanical Garden and to study the flora of that region.

MISS VERA K. CHARLES, scientific assistant in the Bureau of Plant Industry, U. S. Department of Agriculture, has recently returned from the Isle of Pines, where she was collecting in the interest of the herbarium connected with the office of vegetable pathological and physiological investigations.

THE SAMUEL D. GROSS prize of the Philadelphia Academy of Surgery, for the year 1905, amounting to $1,200, has been awarded to Dr. James Homer Wright, of Boston, Mass., for his essay, 'The Biology of the Micro-organism of Actinomycosis.'

THE Wilde medal of the Manchester Literary and Philosophical Society has been awarded to Professor C. Lapworth, F.R.S., professor of geology at Birmingham.

THE St. Petersburg Academy of Sciences has awarded the Lomonosoff prize of $500 to Professor N. A. Menschutkin for his researches in theoretical chemistry, and the Ivanoff prize to Professor P. N. Lebedeff, of Moscow, for his experimental researches on the pressure of light.

AT a meeting of the trustees of the Percy Sladen fund, held recently at the rooms of the Linnean Society, London, grants were made to Mr. W. R. Ogilvie Grant towards the expenses of a collector for the British Museum in Central Africa; to Miss Alice L. Embleton to enable her to continue her investigations in insect cytology; and to Mr. J. Stanley Gardiner towards the expenses of an expedition to the Indian Ocean.

The Carnegie Institution of Washington has recently made a grant of $2,500 to Professor C. F. Burgess, of the department of applied electro-chemistry of the College of Engineering of the University of Wisconsin, to aid him in carrying out investigations upon the properties of pure iron and its alloys. During the past three years Professor Burgess has developed a method of producing iron electrolytically of a very high degree of purity, in a manner similar to that employed in the refining of copper. Previous to this work pure iron has been obtained only in very small quantities and at excessive cost, but Professor Burgess is now able to produce comparatively large quantities at a small cost, using for this purpose a cheap grade of steel. Careful analysis of this product fails to show the presence of any foreign element, with the exception of hydrogen, which can readily be driven off by heat. There is already a considerable demand for this iron for scientific purposes, and about half a ton has been made.

According to the New York *Evening Post* the grants made by the Carnegie Institution for scientific research include the following to Cornell: Professor Wilder D. Bancroft, for chemical study of alloys, $500; W. W. Coblentz, for study of infra-red emission and absorption spectra, $1,000; E. S. Shepard, for study of brasses and bronzes as alloys, $1,000.

We learn from *Nature* that an international committee has been formed in Heidelberg, under the presidency of Dr. A. Freiherr von Dusch, minister of education, of the Grand Duchy of Baden, with the object of honoring the memory of the late Professor Carl Gegenbaur, who for nearly thirty years was the director of the Anatomical Institute of Heidelberg. The committee has decided upon a life-size bust of Gegenbaur, to be executed in marble by Professor C. Seffner, Leipzig. The bust will be placed in the vestibule of the Anatomical Institute, probably in the early summer, at a date not yet fixed. The committee invites former pupils of the deceased master, and all those who have benefited from his epoch-making works on human and comparative anatomy, to send contributions, with their addresses and titles, to Professor M. Fuerbringer or to Professor E. Goeppert, both in Heidelberg. Every contributor will receive a picture of the bust, and casts may be obtained, on special application, from Professor C. Seffner.

A memorial service in honor of the late Professor Alpheus S. Packard was held at Brown University on February 18.

Dr. George Bond Howes, F.R.S., Huxley's successor as professor of zoology at the Royal College of Science, London, known for his contributions to vertebrate morphology, died on February 4, at the age of fifty-one years.

The Rev. Thomas Arthur Preston, who founded the Marlborough Natural History Society and Museum and who did much to promote nature-study in England, died on February 6, at the age of seventy-one years.

Dr. Julius Scriba, professor of surgery at the University of Tokio and the author of contributions on anthropology and botany, has died at the age of fifty-five years.

The United States Civil Service Commission announces that in view of the very small number of applications filed for the examination for assistant in the Philippine service, on March 1–2, this examination has been postponed to April 5–6, 1905, and will be held in different parts of the country, to secure eligibles from which to make certification to fill a large number of positions in the grades of clerk and teacher in the Philippines. As a result of this examination it is desired to secure 140 college graduates, including 20 polytechnic and 20 agricultural graduates, at a salary of $1,200 per annum, and 60 normal school graduates at a salary of $1,000 per annum. Many of the appointees will be required in the position of teacher, while some will be required in the various clerical and administrative offices in the islands. Excellent opportunities for promotion are afforded for well-qualified appointees. For positions requiring college graduates students who graduate in 1905 will be acceptable.

The United States Civil Service Commission announces an examination on March 8, 1905, to secure eligibles from which to make

certification to fill a vacancy in the position of botanist (male) at $75 per month, in the National Museum, and vacancies as they may occur in any branch of the service requiring similar qualifications. The commission also invites attention to the examination for scientific aid, applications for which may be filed at any time. Eligibles are particularly desired at this time to fill a vacancy in the position of scientific aid (male) qualified in animal husbandry, in the Bureau of Animal Industry, Department of Agriculture, at $480 per annum, and other similar vacancies as they may occur in that department. For the specific vacancy mentioned, only such applications will be considered as are filed with the Commission at Washington prior to the hour of closing business on March 8, 1905.

THE N. Y. State Civil Service Commission will hold an examination on March 1, to fill the position of geologist in the State Museum at a salary of $1,500, and of taxidermist in the Museum at a salary of $900.

THE Court of Appeals of Maryland has just rendered a decision which establishes the constitutionality of the State Aid Highway Law of the last legislature, the administration of which has been by law placed under the control of the Maryland Geological Survey. The state survey has maintained a highway division during the past eight years, but has now placed at its disposal $400,000 annually, derived half from the state and half from the counties, for the construction of improved highways. The law becomes operative at once and surveys on a large scale will begin immediately.

THE Argentine gunvessel *Uruguay* has returned to Buenos Ayres after her long voyage in the Antarctic seas, having failed to obtain any news of the French Antarctic expedition under Dr. Charcot.

MR. DAVID SYME, of Melbourne, has given $15,000 to found a prize for the encouragement of original research in science. A prize of $500 and a medal will be annually awarded by the University of Melbourne.

THE London *Times* states that it received the following letter for publication from a correspondent who is a graduate of an English university, but presumably did not specialize in scientific subjects: "The Amount of Coal.—To the Editor of *The Times*.—Sir, —The amount of coal which has been dug out of the earth must be now so considerable as to make an appreciable diminution of the weight of our globe. Is it conceivable that in time this might cause an interference with the working of the solar system. All of the coal that remains behind is a small proportion, in ashes; the only addition that is made to the weight of the earth is by increase of population, and is infinitesimal. I am, Sir, yours faithfully, W. C. B."

MR. ANTONIO OLYNTHO, Brazilian commissioner to the Louisiana Purchase Exposition, has, by order of his government, investigated the organization and work of the division of hydrology of the U. S. Geological Survey. The underground water resources of Brazil, which are as yet almost entirely undeveloped, are said to be immense. It is the wish of the Brazilian government to encourage their development, and to this end it is proposed to organize a division of hydrology similar to that maintained by the U. S. Geological Survey. The investigation and development of artesian waters is of particular interest to the Brazilians. As compared with the work of bureaus in other countries, the investigations carried on by the U. S. Geological Survey of both surface and underground waters takes high rank, as is attested by the frequent calls from other governments for information and assistance. During the past year, the Colonial Office of Bermuda has sought advice from our Survey in regard to a water supply for that island, and the government of Peru has borrowed a hydrologist, who is organizing a bureau which is investigating the underground waters of that country in the special hope of obtaining supplies for the nearly rainless coast. The bureau which Brazil proposes to establish will be modeled after the survey's division of hydrology, the plan of which was furnished the commissioner from Brazil by Mr. Myron L. Fuller chief of the eastern section. The work in Brazil will differ, however, in one important particular

from that in the United States. The drilling of test wells by the government survey has seldom been practicable here, but the government of Brazil, like that of Peru, expects to actually drill for water, and drilling outfits have accordingly been purchased in this country for that purpose.

UNIVERSITY AND EDUCATIONAL NEWS.

THE University of Pennsylvania has asked from the state an appropriation of $650,000 to be used as follows: (1) University hospital—maintenance, $140,000; new building, $75,000; clinical amphitheater and laboratories for dispensary buildings, $35,000; (2) university—$175,000 for general maintenance, construction of buildings, and the purchase of apparatus; (3) veterinary department—$100,000 for the erection of a suitable building and equipment; (4) free museum of science and art—$125,000 for the construction and equipment of a building for the expansion of the department.

MR. CHARLES H. HACKLEY, of Muskegon, Mich., has made public bequests, as follows: To the Hackley Manual Training School of Muskegon $250,000 is given, which, added to $360,000 already given by Mr. Hackley, makes the school's total endowment $610,000; as an endowment for the Hackley Hospital, $300,000, less any sum given during Mr. Hackley's lifetime for this purpose; for the maintenance of the Hackley Public Library, $200,000; for the purchase of pictures for this library, $150,000.

MOUNT HOLYOKE COLLEGE will receive $172,000 as the residuary legatee of Edmund K. Turner.

THE Drapers' Company have voted a further sum of £400 a year for five years towards the statistical work and higher teaching of the department of applied mathematics, and the Mercers' Company have voted £1,000 to the chair of physiology, in University College, London.

WE learn from *The Experiment Station Record* that W. C. Stubbs, who has been since 1885 professor of agriculture in the Louisiana State University and director of the experiment stations, has voluntarily retired. He is succeeded by Professor W. R. Dodson, who becomes, by virtue of his office as professor of agriculture at the university, director of the three stations in the state, director of the State Geological Survey, official chemist, etc.

MR. THORNE M. CARPENTER has resigned his position as assistant chemist and assistant in the investigations with the respiration calorimeter, of the Agricultural Station of the Pennsylvania State College to accept a similar position in connection with the investigations on human nutrition at Wesleyan University. The vacancy has been filled by the promotion of Mr. N. C. Hamner, and Mr. W. A. Smith, a graduate of the college in 1901, has been appointed assistant chemist. Mr. J. B. Robb, of the Maryland Agricultural College, who has assisted in the respiration calorimeter investigations during the past three winters, has been temporarily engaged for the same purpose for the present season.

MR. F. L. SHINN, assistant in physical chemistry at the University of Wisconsin, has just accepted a call to the University of Indiana, as assistant professor of physical chemistry.

M. JONATHAN RIGDON, fellow of Clark University, has been appointed instructor in philosophy in Clark College.

MR. H. H. HIGBE, assistant in mechanical engineering at Columbia University, has been appointed instructor in the University of Michigan, and Mr. L. F. Parr has been appointed to fill the vacancy at Columbia University.

MR. EDGAR SCHUSTER, M.A., New College, Oxford, has been appointed to the Francis Galton research fellowship in national eugenics.

MR. I. L. TUCKETT, M.A., of Trinity College, Cambridge, has been appointed demonstrator in physiology.

M. MICHAEL-LÉVY has been nominated by the Paris Academy of Sciences for the chair of inorganic chemistry at the Collège de France, vacant by the death of M. Fouqué. M. Cayeux is named as the second choice of the academy.